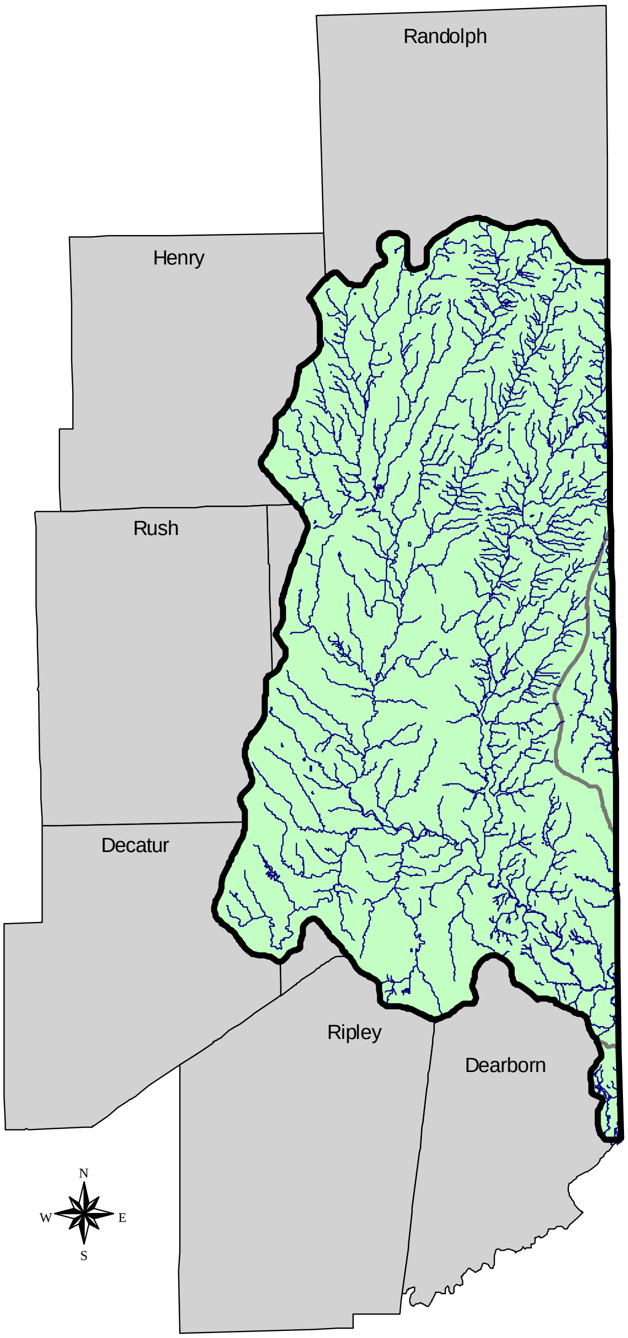
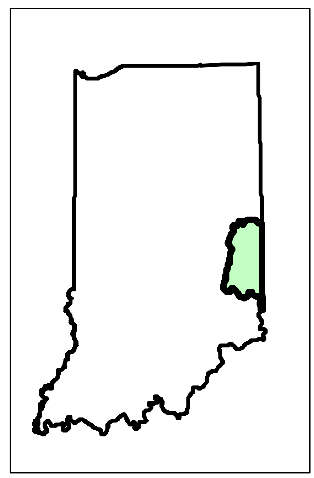
1997 Synoptic Sampling Surveys in the Whitewater River Basin

Surveys Section
Assessment Branch
Office of Water Management





IDEM
INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

1997 Synoptic Sampling Surveys in the Whitewater River Basin

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INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
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Abstract

In 1997, the Surveys Section of the Assessment Branch, Office of Water Management, operated multiple surface water quality monitoring programs within the Whitewater River Basin. These programs, operated in conjunction with the Assessment Branch's Surface Water Quality Monitoring Strategy (IDEM 032/01/013), included the Probabilistic Monitoring Program, the Fixed Station Monitoring Program, and the Synoptic Monitoring Program. These programs were designed to collect chemical water quality data, from both targeted and probabilistically selected sites, in order to develop a comprehensive assessment of the overall surface water quality of the Whitewater River Basin.

The Synoptic Monitoring Program component is described in this document. The sites selected were targeted in such a way as to give an overall even spatial distribution coverage. Then each site was evaluated as to its upstream land use. Sites were sampled six times on average over the year to give seasonal coverage. Basic water quality parameters were chosen to characterize the sites. Flow measurements were made at selected sites and data from the U.S.G.S. gaging stations were collected in order to help with chemical data interpretation. This report summarizes the data collected from the Whitewater River and discusses the results.

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EXECUTIVE SUMMARY

This document is one in a continuing series covering the activities of the Surveys Section of the Indiana Department of Environmental Management, Office of Water Management, Assessment Branch. The Surveys Section, in 1996, initiated synoptic water quality sampling surveys according to its new monitoring strategy. This strategy is described in the Office of Water Management document titled, *Surface Water Quality Monitoring Strategy 1996-2001* (IDEM 1996). The East Fork of the White River and the Whitewater River Basins were monitored in 1997 as required by the monitoring strategy. This strategy has since been modified, and the objectives of the synoptic sampling surveys have been included in other programs. See the *Surface Water Quality Monitoring Strategy 1998-2001* (IDEM 1998).

One main objective of these surveys was to describe the environmental water quality of the surface water resources in these basins, and to identify what parts of the watersheds were exhibiting signs of existing or emerging problems. This was primarily accomplished by looking at water quality stream standards and by comparing sub-watersheds with each other.

Sampling sites for this project were selected in a way that gave an overall even spatial distribution coverage. Then, each site was evaluated as to its upstream land use. Sites were sampled six times over the year to give seasonal coverage. Basic water quality parameters were chosen to characterize the sites. Flow measurements were made at selected sites, and data from the USGS gaging station sites were collected to help with the chemical data interpretation. Special sampling methods were followed which are referenced in this report. Samples were analyzed by a contract laboratory. Results were entered into the Surveys Section database. Quality assurance and quality control guidelines were followed throughout the process.

This report summarizes the data collected from the Whitewater River Basin, and discusses the results. A narrative on sampling protocol is presented followed by a section on the geography and geology of the study area. Then, four main parameter groups are discussed: nutrients, heavy metals, general chemistry, and bacteria. A general discussion of each parameter is given followed by results for the sampled areas. Conclusions and recommendations are presented in each section.

The highest suspended solid concentrations and loadings in the Whitewater River Basin occurred at the Alpine site. The sampling sites of most concern for nutrients in this basin are in the Whitewater River around Connersville, in the East Fork Whitewater River downstream of Richmond, and around the Abington area. Some elevation of nitrate values were found here. Also, Martindale Creek, Greens Fork and Nolands Fork were sites with higher nitrate levels. Blue Creek had high Total Organic Carbon (TOC) values when compared with the other tributaries of the Whitewater River.

Only two sites were found to have water quality criteria violations for metals, and they were Williams Creek near Connersville and Whitewater River south of Hagerstown. Over all, this is a low percentage of water quality criteria violations, and shows that the Whitewater River Basin is not significantly impaired by the metals assessed.

The general chemistry data collected for this basin showed that the Brookville Reservoir had a notable impact. Primarily it reduced all of the general chemistry parameters. Except for chlorides, the general chemistry parameters slowly but steadily decreased in concentration. No water quality violations for dissolved solids, sulfates, or chlorides were found in the data collected for this basin.

The main stem of the Whitewater River exhibited only a few *E.coli* counts over Water Quality Standards. One tributary, Blue Creek, was consistently high and over the standard. The East Fork of the West Fork Whitewater River data showed a recurring problem in the Richmond area.

This sampling gives an initial snapshot of water quality in the study areas. In the future, the areas will be resampled and more in-depth trend analyses will become possible over time. Until the new monitoring strategy was initiated, not enough data had been systematically collected State wide to do the necessary in-depth analysis to describe the water quality of the State and to answer the questions posed about it. As time goes on, these types of surveys combined with biological data can describe the trends in quality of the surface waters of Indiana with a much greater certainty.

I Introduction

by

Mark A Holdeman

In the past, Indiana as well as the rest of the nation have invested a large amount of time, energy, and money on solving and preventing water quality problems. Although billions of dollars have been spent on improving surface water quality nationwide, no comprehensive measurement of change in the environment has been made to show what good has been done to achieve the objectives of the Clean Water Act[1]. To help solve this continuing dilemma, a new monitoring strategy for surface waters of Indiana (IDEM 1996) was initiated in 1995 by the Assessment Branch of IDEM's Office of Water Management (OWM). In 1996, as one part of this new strategy the Surveys Section of the Assessment Branch began water quality sampling of the West Fork of the White River and Patoka River. During 1997, the strategy was continued with monitoring of the East Fork of the White River and the Whitewater River.

The primary purpose of this specific activity was to provide benchmark information for long term trend analysis along with a large scale overview of surface water quality for these watersheds. Also, an examination of these data relative to the State's water quality standards was done and emerging problems were identified. This new OWM assessment strategy called for synoptic sampling over several seasonal periods in the same respect as the IDEM Fixed Station Program, but on a much more intense spacial scale to present a more comprehensive overall assessment.

This document presents the data collected from the 1997 Synoptic Sampling Survey of the Whitewater River. A look at some selected basic environmental indicators and pollution parameters is reported here. Also, an effort to assess the surface water quality with respect to the seasons was made to identify the temporal influences of weather, land use, and other unknown factors.

In the past, most intensive surface water quality stream sampling was carried out during low flow conditions primarily to assess point source effects on downstream reaches. The new protocol allows sampling at various flow stages and times to assess the whole range of seasonal effects and to show the changes and movement of contaminants. Each major tributary in the study area

[1] Intergovernmental Task Force on Monitoring Water Quality, December 1992. *Ambient Water-Quality Monitoring in the United States, First Year Review, Evaluation, and Recommendations* [condensed from Executive Summary]. Intergovernmental Task Force on Monitoring Water Quality, Interagency Advisory Committee on Water Data, Water Information Coordination Program, Washington D.C.

was examined to see the contributions it makes to the main stem. A wide coverage of the geographical study area was undertaken. As many sites as possible, relative to the resources of the Surveys Section, were used to help with interpretation of trends and to show where problems exist.

In the future, it is hoped that these types of surveys can be improved upon and perpetuated to help answer the most important questions about the surface water quality of the state of Indiana. As the various watershed basins are resampled, a continuing comparison can be carried on to describe with greater accuracy the surface water quality trends of the streams and rivers of Indiana.

II Synoptic Sampling Protocol and Methods

by

Sammy C Gibson

In the early 1970's, the Water Quality Surveys Section of the Indiana State Board of Health divided State watersheds into 99 separate geographical units called stream segments. The size of the segments varied primarily according to pollution abatement needs that existed in the area. For example, the cities of Salem (segment 91, Upper Blue River) and Booneville (segment 90, Cypress Creek) are focal points for segments with drainage areas of less than 70 square miles**.** In contrast, segment 14 (Lower Kankakee River) has a drainage area of 812 square miles.

Site locations and identification numbers for the 1997 synoptic sampling were based on the Indiana segment numbering system. Hydrologic unit code designations, a numbering and defining system developed by the United States Geological Survey, were added after the site list was completed. Major hydrologic units are large and may encompass more than one designated segment.

Synoptic sampling is an exercise designed for determining the general picture of basin surface water quality rather than concentrating on known point source areas. Sampling locations were chosen to reflect both in numbers and spatial variation the primary influences that may affect surface water quality and biological integrity. Topographic maps (1:100,000) of the watersheds were used to place sampling sites spatially.

Site Selection Criteria

U.S. Geological Survey Flow Monitoring Stations

Stream flow data are necessary for calculating pollutant loadings. The United States Geological Survey (USGS) operates several stream flow gaging stations that are in diverse areas and provided a good starting point for sample site selection. Five (5) synoptic sampling sites were selected at gaging stations in the Whitewater River Basin. By taking gage readings at the time of sample collection, real-time flow data are available.

State of Indiana Fixed Station Monitoring Program

In 1957, the State of Indiana initiated its Water Quality Monitoring Program to monitor selected surface waters routinely. Starting with approximately 49 sampling locations, this program has gone through many changes and numbered 105 sites in 1997. Many fixed stations were initially chosen because of known point source discharger problems, but some stations were selected on streams not considered adversely affected by any dischargers. Data from these "reference" sites are used to help evaluate data from sites suspected of higher degrees of degradation.

Two (2) fixed station sampling sites in the Whitewater River Basin were selected for synoptic sampling. These stations provide historical data for comparison with data gathered during the current program. Many fixed stations are found at USGS gaging station sites, so historical flow data are also available.

Tributary Confluences and Drainage Areas

The stations selected under the first and second criteria are primarily on the main stems of the respective streams. Most major tributaries were sampled as near as possible to their confluence with the main stem. Some tributaries were sampled at more than one site depending on the drainage area and land use diversity. Generally speaking, a ratio of one sample site per approximately 70 square miles of drainage area was used as a guide post during the selection process.

Land Use Influence Factors

After selection was made from the fixed stations, gaging stations, and tributary confluence sites, further selection involved upper reaches of the tributaries or any areas of the main stems not considered adequately represented. These selections were based on land use factors, with drainage areas as a secondary consideration. Stations selected during this phase of the process were categorized as primarily influenced by one or more land use activities.

Land use factors were divided into six general categories. Although site selections were made primarily to represent one major group, multiple influences were usually present. The six major groups were:

Table II·1 Land use and possible related water quality influences

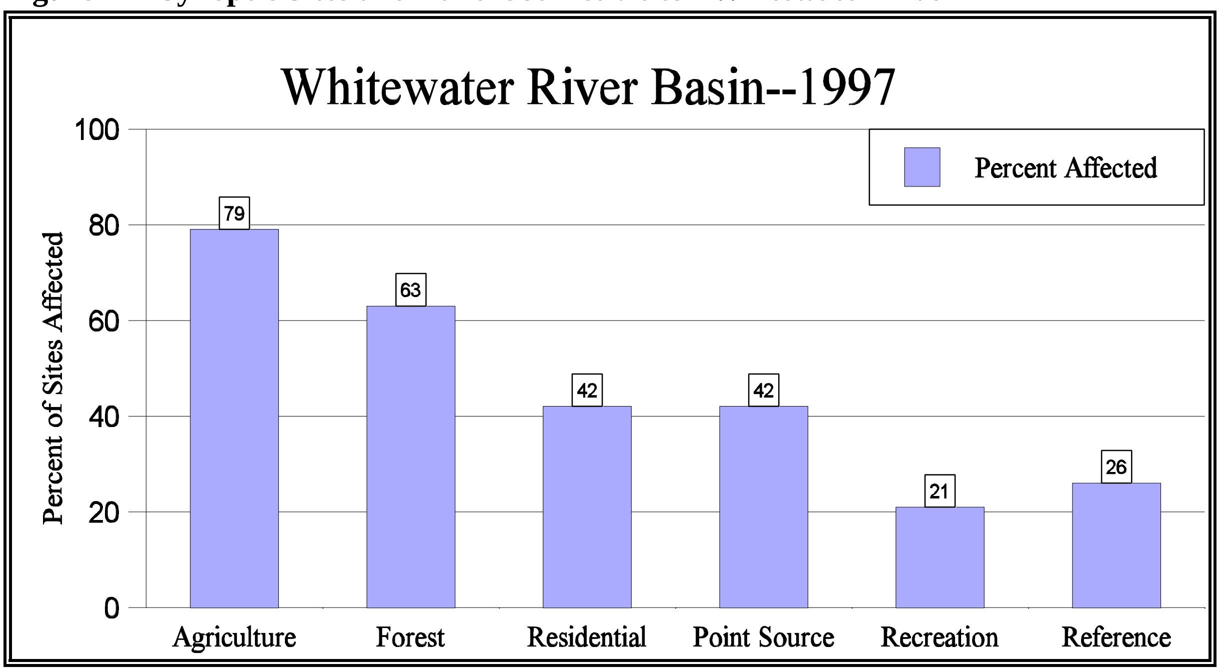
Activity	Potential Adverse Effects on Water Quality
Agriculture and related operations	Run off from seed bed preparation, row crops, cover crops, pasture, confined feeding (including land application of wastes)
Forest and Woodlands, Rural	Rural, undeveloped, state forest areas, few row crops, low population density, few unnatural effects on streams
Urban, Concentrated Residential	Densely populated, street run off, construction site run off, failing septic systems, combined sewer overflows

Activity	Potential Adverse Effects on Water Quality
Point Sources	NPDES dischargers
Recreational	Known areas of extensive use of waters for boating and other recreational activities
Reference	Isolated, sparse population, no obvious anthropogenic impacts

Some sites were noted because they were upstream or downstream of a reservoir, near a fish and wildlife area, or the last site at the discharge point of the segment. A few sites were selected to supplement biological studies conducted at those locations.

After all sites were selected, the numbers of sites affected by one or more of the listed land use criteria were tabulated. Figure II·1 shows the percentage of sites affected by one or more of the selection criteria. Totals will be more than 100 per cent because of multiple influences.

Figure II·1 Synoptic Sites and Land Use Activities - Whitewater River



A total of nineteen sampling sites were selected. This averaged out to approximately one sample site per 72 square miles of drainage area, which was very close to the original projections of 1:70. A table listing sample sites and related selection criteria can be found in Appendix A.

Sampling Logistics

The sites were arranged into two routes, going downstream from the headwaters of the basin. Routes were designed to reduce collection time and to allow expedient delivery of samples to the water laboratory. A staff member was assigned as crew chief for each route to maintain consistency of all activities relating to that route. Each route required two days to complete.

Objectives of the synoptic sampling program include determining overall water quality and defining any significant changes during varying conditions. Most sites are directly influenced by agricultural activities. Therefore, the cycle of seed bed preparation, planting, harvest, fall plowing, and nutrient/pesticide application was the major factor in sample scheduling. Other factors considered were seasonal rainfalls, expected variation in stream flows, and weather changes overall. Table II·2 lists the sampling periods for 1997:

Table II·2 Sampling Periods for 1997

Dates	Conditions and anticipated influences
March 05 to March 21	Late winter, high stream flow, short days, low water temperature, some early seed bed preparation with fertilizer applications
April 18 to May 02	Spring, extensive seed bed preparation and fertilizer applications, high to medium stream flow, longer days, warmer air and water temperatures
May 29 to June 13	Late spring, possible start of second fertilizer applications, stream flows usually start to fall toward summer levels
July 10 to July 25	Midsummer, warm and dry conditions, second fertilizer applications in areas where crops were planted late, lower stream flows
September 16 to October 03	Early fall, usually hot and dry, time for algae blooms and significant low flow conditions, leaf fall may begin
November 12 to December 04	Late fall, still some low flows but lower stream and air temperatures, days very short with little photosynthesis

Sampling Methodology

Grab samples for laboratory analyses were collected from the visual center of the flow. A special sampler was designed to hold the sample bottles, and collect the samples directly rather than using an intermediate container. Latex gloves were worn by the sample collector always during the handling of the sampling device or the sample bottles. The sampling device was rinsed with de-ionized water after each use and placed in a plastic bag for transport to the next site. Preservatives were added to appropriate samples. All sample bottles were rinsed with deionized water and kept in ice filled coolers for transport to the water laboratory. Reagent blanks, duplicate samples, and matrix spike samples were submitted as required.

Field tests for dissolved oxygen, temperature, pH, conductivity, and turbidity were conducted each time a sample was collected. A HydroLab H20™ multi-probe transmitter sonde, with a stirring unit, and Scout 2 ™ display unit were used for these tests. Samples were collected with a plastic bucket from the center of the flow and poured carefully into a specially designed container (PVC tube). The probe unit was then submerged in the tube and readings taken. This tube also provided a safe carrying mechanism for the very sensitive sonde probe during transit between sites. All pieces of equipment were rinsed with sample water before sample collection and testing.

The multi-probe electronic testing devices were calibrated in the office before each sampling trip. Comparative field testing for dissolved oxygen, pH, and turbidity was done at least once per day during field work. The Winkler method was used for dissolved oxygen comparisons. A calibrated Cole-Parmer Model 5985-80 Digi-Sense ™ pH meter and a Hach 2100-P turbidimeter were used to check calibrations for those parameters.

Physical characteristics at each site and ambient weather conditions were noted in check lists on the stream survey field sheet. Stream discharge data were taken at the available USGS gaging stations at the time samples were collected. Cross-sectional discharge measurements were made at certain designated wadeable sites on the smaller streams. A portable current meter and top-setting wading rod were used to find depth and velocity.

Data Presentation

One method for displaying data is box-whisker plots. The box portion of the plot encloses the 25^{th} to 75^{th} percentile (the center portion of the data). This range is called the interquartile range. The median (50^{th} percentile) is represented by a small square within the box. Data values less than the 25^{th} percentile and greater than the 75^{th} percentile are represented by horizontal lines called whiskers extending from either side of the box. These whiskers extend up to 1.5 times the interquartile range from either side of the box. Data points that are greater than 1.5 times the interquartile range, but less than three times the interquartile range from either side of the box are considered outliers and are represented with a small circle. Data points that are more than three times the interquartile range from either side of the box are considered extremes and are represented as an asterisk.

Another method for displaying data is a histogram. A histogram divides a population into groups by numeric value. These groups are represented on the x-axis. Each group is defined by two numbers, a lower number to the left and an upper value to the right. The rounded bracket on the left (the exclusive bracket) shows the group does not include the value while the squared bracket to the right (the inclusive bracket) shows the group includes this value. The number of observations in each group is shown by the height of each bar in the histogram. Further, the percentage that each group contains of the entire population is found above each bar. A normal curve is overlaid on the histogram to show how the data approximates a normal distribution. The apex of this curve is the mean of the population. (StatSoft, Inc. 1998)

III Geography, Geology, Hydrology, and Suspended Solids Loadings

by

J Larry McFall

Introduction

The geography and geology of any watershed have both anthropogenic and natural influences upon the water quality of that entity. Suspended solids loadings are intrinsically related to the type of human activity and the geology within that watershed. This report gives a general background on both disciplines as they exist in the Whitewater River Basin followed by a presentation of suspended solids concentrations and loadings. All suspended solids and flow data were gleaned from the Surveys Section 1997 synoptic sampling events and the United States Geologic Survey gaging station records.

Geography

The headwaters of the Whitewater River Basin begin in east central Indiana in southern Randolph County just southeast of the small town of Huntsville (Fig III·1). The River courses its way in a southerly direction to Franklin County where it turns southeast and flows to the Ohio state line. Within Ohio it continues an additional 7.98 miles to a confluence with the Great Miami River and thence to the Ohio River. The largest tributary is the East Fork Whitewater River originating in Ohio just south of the small town of New Madison. It follows a course southwest into Indiana (Wayne County), and then turns south to a confluence with the Whitewater River in Franklin County. Overall lengths of the Whitewater River and East Fork Whitewater Rivers are 96.9 miles and 55.4 miles respectively. Total river and stream mileage in the Whitewater River Basin is 1,479.2 miles with 1,007 of these miles being perennial or continuously flowing water (USEPA Surf Your Watershed Web Site 1998).

Whitewater River Basin encompasses a drainage area of 1,369 square miles and has a perimeter of 207.63 miles. Individually the East Fork Whitewater River drains 382 square miles of this total. Other significant tributaries with at least 50 square miles of drainage area are Salt Creek (117 square miles), Nolands Fork (102 square miles), Greens Fork (94.4 square miles), Martindale Creek (70.7 square miles), and Pipe Creek (67.2 square miles) (Hoggat 1975).

Figure III·1 Location of Whitewater River Basin and USGS Gaging Stations

Gaging Stations in the Whitewater River Basin
Rivers and Streams within the Whitewater River Basin
Whitewater River Basin

The Whitewater River drains all or portions of ten east central and southeastern Indiana counties. The City of Richmond is situated on the upper reach of the East Fork Whitewater River in Wayne County, and is the largest population center in the basin with a census count of 39,000 people (US Census Bureau Web Site 1997). Some manufacturing enterprises in Richmond involve the production of compact disks, pet foods, plastics, wire and cable. Connersville is found on the central portion of the Whitewater River in Fayette County and is the second largest city with a population of 26,000 people. Visteon Corporation manufactures automotive air-conditioning components and is by far the largest enterprise in Connersville employing 3,700 people. Other small towns in the basin with populations between 1,500 and 3,000 people include Liberty (2,700), Brookville (2,694), Centerville (2,398), Cambridge City (2,091), and Hagerstown (1,835).

The Brookville Lake impoundment is on the East Fork Whitewater River. Construction of the reservoir began in 1965, was completed in 1975, and was built primarily for flood control, water supply, general recreation, and wildlife opportunities. Brookville Lake is the dominating geographic feature of the lower reach of the East Fork Whitewater River watershed. At normal summer pool stage the lake covers 5,260 acres, has a navigable length of 16 miles, and is one mile wide at its widest point (Brookville Chamber of Commerce, via personal communication 1997). The scenic and pristine qualities of Brookville Lake and the lower reaches of the Whitewater River Basin create popular outdoor recreation attractions for this area and an influx of water sport enthusiasts during the summer months.

Land use in the Whitewater River Basin is primarily agriculture accounting for approximately 81 percent of all usage. Agricultural activity includes row crops of corn, soybeans, and wheat. Some agriculture is dedicated as pastureland for which cattle and hogs are primarily the animals raised. Other significant usages include forest (52%) and urbanization (1%). The total percent sum exceeds 100 percent due to overlapping influences in many areas (USEPA Surf Your Watershed Web Site 1997).

The climate in the Whitewater River Basin is considered as temperate or moderate. Typically the basin has humid conditions with well-defined summer and winter seasons. Seasonal temperatures range from a mean of 28°F in January to 75°F in July. Mean annual temperature is 52°F. Precipitation varies from 4.3 inches in March to 2.5 inches in October. Mean annual precipitation in the basin is 41 inches (Govenor's Water Resource Study Commission 1980, p 376).

Geology

Elevations vary from approximately 1,200 feet in the uppermost headwaters in Randolph County to 490 feet where the Whitewater River crosses the Indiana State Line and flows into Ohio. This is a fall of approximately 710 feet over the course of the Whitewater River Basin.

The major geologic feature of the Whitewater River Basin is the Cincinnati Arch (Malott 1922). The crest of this arch tends in a northwest direction and bisects the Whitewater Basin with the rocks of the crest positioned nearly horizontal. Rocks of the western side dip to the west-southwest at an average of 25 feet per mile into the Illinois Basin. The rocks on the eastern side dip to the east and northeast at a similar rate into the Appalachian Basin (Martin and others 1996, p 159).

The two physiographic units existing in this basin are as described:

Tipton Till Plain - This unit is within the northern one-third of the basin, and is characterized by a plain of flat to rolling relief composed of thick glacial deposits that cover the underlying bedrock topography. Headwater tributaries of the Whitewater include the West Fork, Greens Fork, Nolands Fork, and East Fork. These are incised into the till plain and have local relief of greater than 100 feet.

Dearborn Upland - This unit is an extremely dissected bedrock plateau of rugged relief that overlays nearly flat limestones and shales. A glacial till 15 to 50 feet thick covers the top of the plateau characterized by deeply eroded valleys from rapid ice melts. The landscape of this unit is well drained by virtue of steep slopes, high drainage density, and poorly permeable rocks and soils (Martin and others 1996, p 157-158).

Hydrology

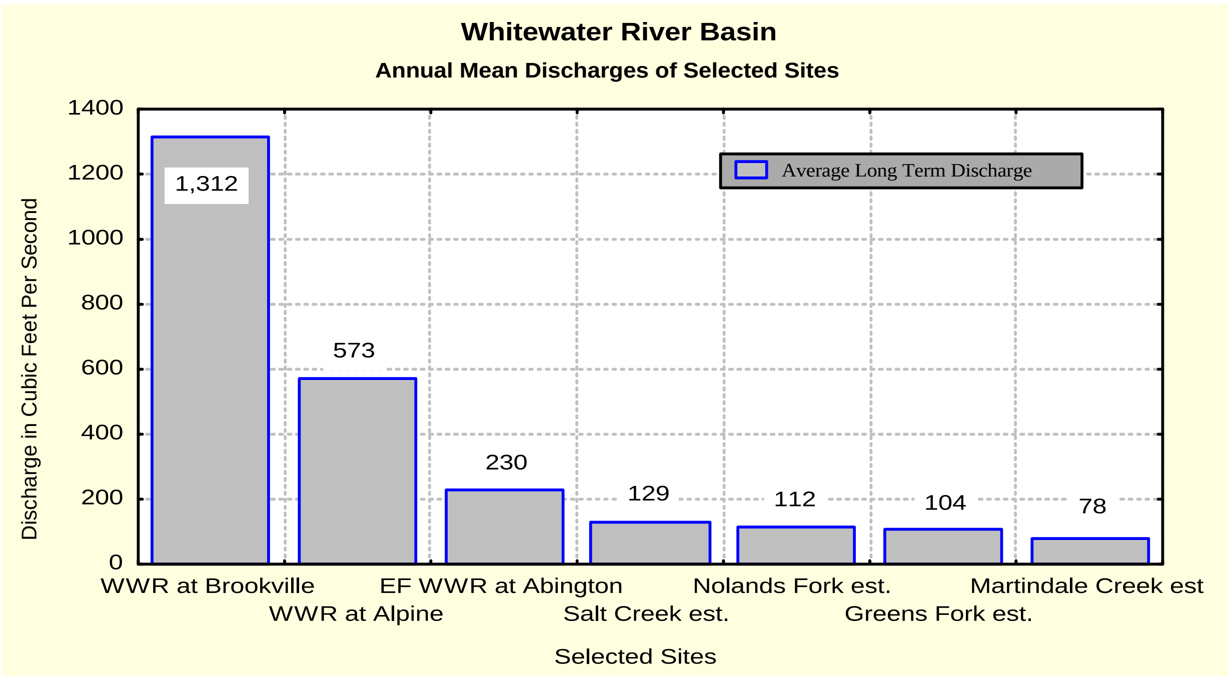
To assess the hydrology of the Whitewater River Basin, three USGS gaging stations with long periods of record were available at pertinent locations for historical flow data evaluation (Figure III·1). Two of these sites are on the main stem Whitewater River near Alpine, and at Brookville after the confluence with the East Fork. The third site is on the East Fork Whitewater River above Brookville Lake at Abington.

The average long term discharge of the Whitewater River as measured at the USGS gaging station at Brookville is 1,312 cubic feet per second (cfs). This represents approximately 1.5 billion cubic yards of discharge from the basin in an average year. Average long term discharges of the Whitewater River at Alpine and the East Fork Whitewater River at Abington are 573 cfs and 230 cfs respectively.

Average long term discharge contributions for the three gaging stations shows a close correlation to the drainage area. Calculation of the ratio of drainage area (square miles) to average long term flow (cfs) showed the average ratio to be 0.91:1 for the three sites with a standard deviation of only 0.026. Most of the discrepancy was observed at the gaging station on the East Fork Whitewater River at Abington where the drainage area of 200 square miles compared with 230 cfs average long term discharge or a 0.87:1 ratio.

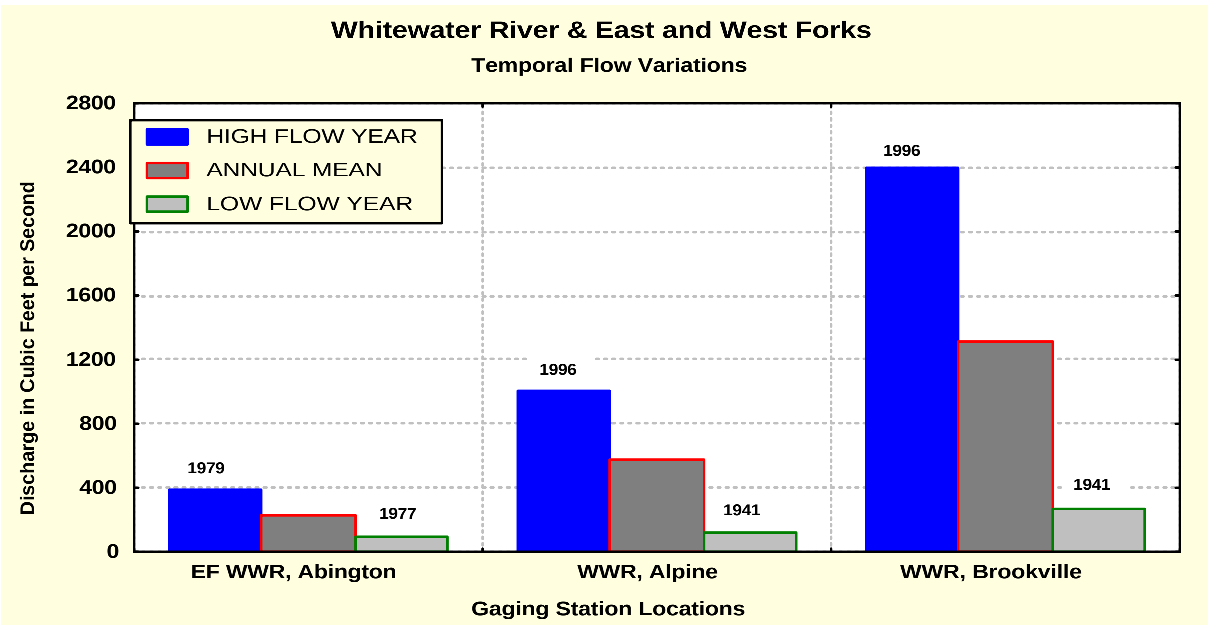
Consistency of drainage area to flow ratios in the Whitewater River Basin can be used to estimate discharge contributions from major tributaries that are lacking gaging station data. The Salt Creek watershed makes up approximately 8.5% of the drainage area in the basin and has an estimated average long term discharge of 129 cfs. Other major tributaries include Nolands Fork, Greens Fork, and Martindale Creek, and they have estimated average long term discharges of 112 cfs, 104 cfs, and 78 cfs respectively (Figure III·2).

Figure III·2



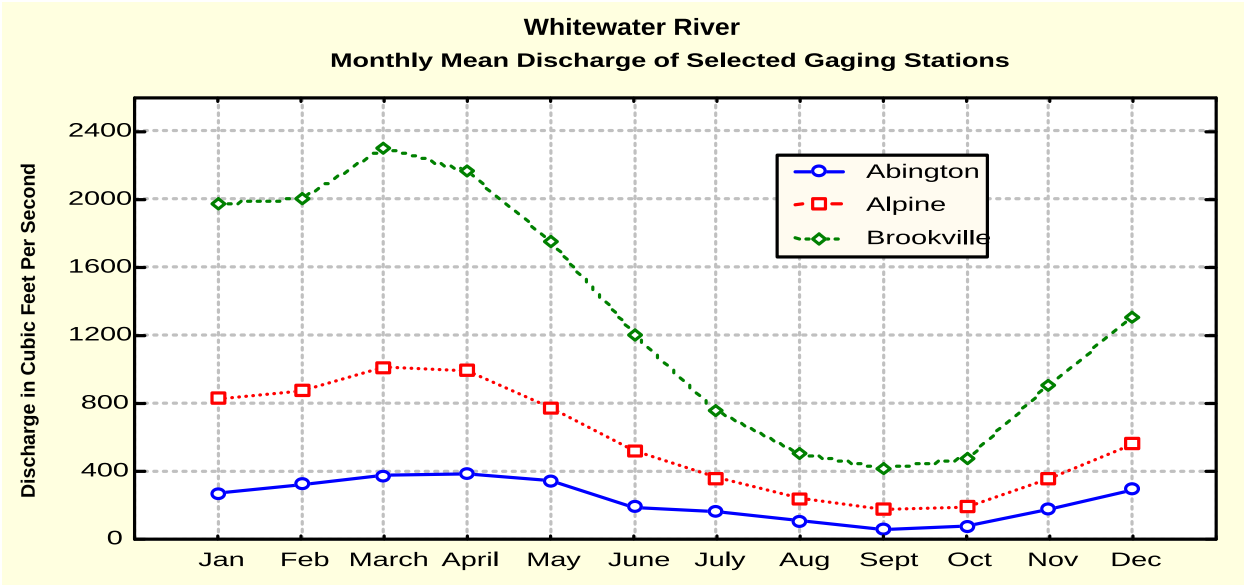
During the period of record, temporal variations in stream flow fluctuate unpredictably from year to year at three selected gaging station sites. Extremes of this fluctuation can be exhibited by observing the highest annual mean, the annual mean, and the lowest annual mean for each of these sites. Wet and dry year occurrences coincide for the main stem gages at Alpine and Brookville. Nineteen ninety-six was the extreme wet year, and the driest year occurred in 1941. The Abington gage on the East Fork Whitewater River had a much shorter period of record and registered the wet and dry year occurrences in 1979 and 1977 respectively (USGS 1998). Brookville gaging station had the greatest variation in flow from the wettest year (1,312 cfs) to the driest year (271 cfs), showing an increase of 8.8 times between the extremes. The Abington gage only showed a 4.2 increase between the wet (388 cfs) and dry (92.3) years (Figure III·3).

Figure III·3



Seasonal extremes in flow were observed by comparing the lowest monthly mean and the highest monthly mean for three selected gaging stations during the period of record (Figure III·4). All three gaging stations were observed to have the lowest discharges during September. Monthly means of 57 cfs, 177 cfs, and 409 cfs were recorded for the East Fork Whitewater at Abington, the main stem at Alpine, and the main stem at Brookville respectively. The highest monthly means were registered in the spring during March for Alpine (1,015 cfs) and Brookville (2,296 cfs). The highest monthly mean for Abington occurred in April where 385 cfs was observed.

Figure III·4



Flow stage data for the sampling events conducted in 1997 show that March (normally a high flow month) had the highest flow stages for the Abington and Alpine sites (Figure III·5a through III·5c). The Brookville site registered an extremely high flow during June and that was probably due to a controlled release from the Brookville Lake dam at this time. The singular highest flow stage for all sampling events was monitored at this time when 5,965 cfs was observed at the main stem Brookville gaging station. Low flow events occurred during the fall (late September or early October) for all three sites. The Abington and Brookville sites had abnormally low flow in relation to the monthly means for these gaging stations. A flow of 18.3 cfs at Abington was just barely above the $Q_{7, 10}$ (the projected seven day low flow period that will normally occur every ten years) of 18 cfs. The Brookville gage flow of 59 cfs was well below the $Q_{7, 10}$ of 102 cfs showing very dry weather for this sampling event.

Figure III·5a

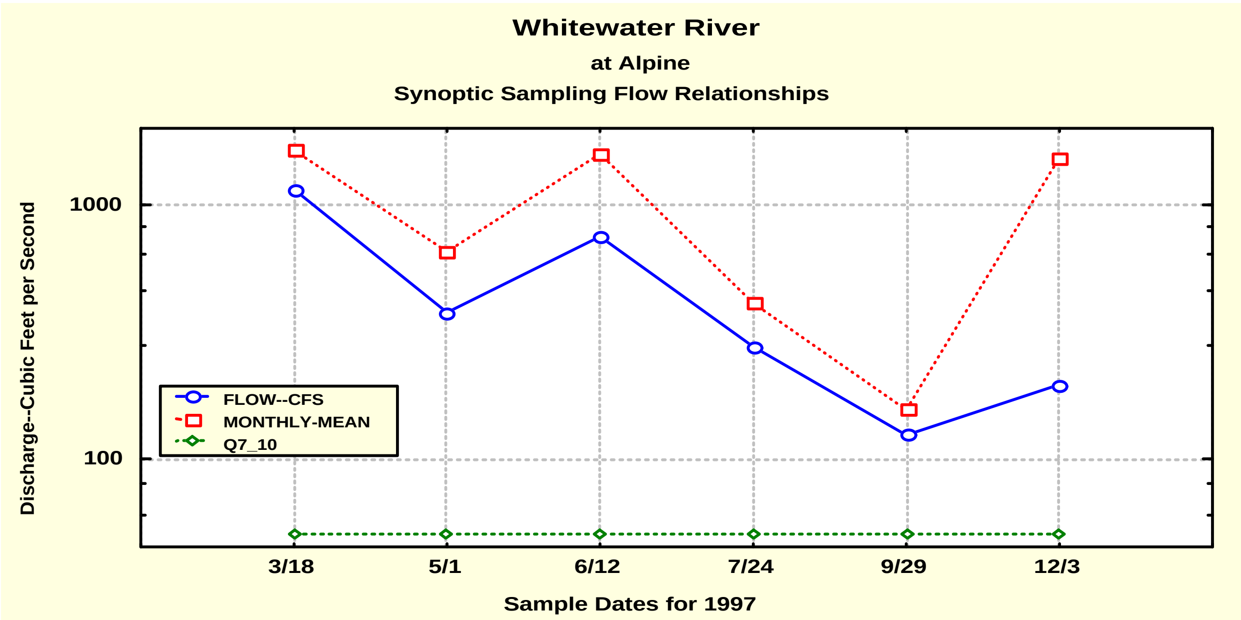


Figure III·5b

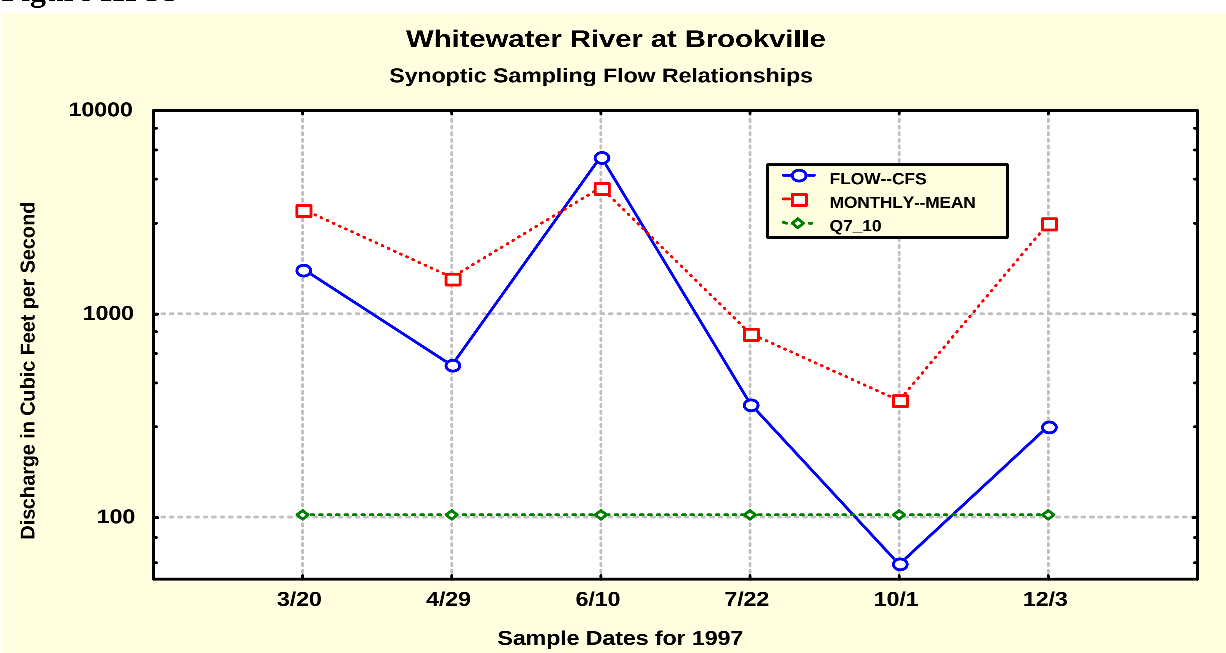
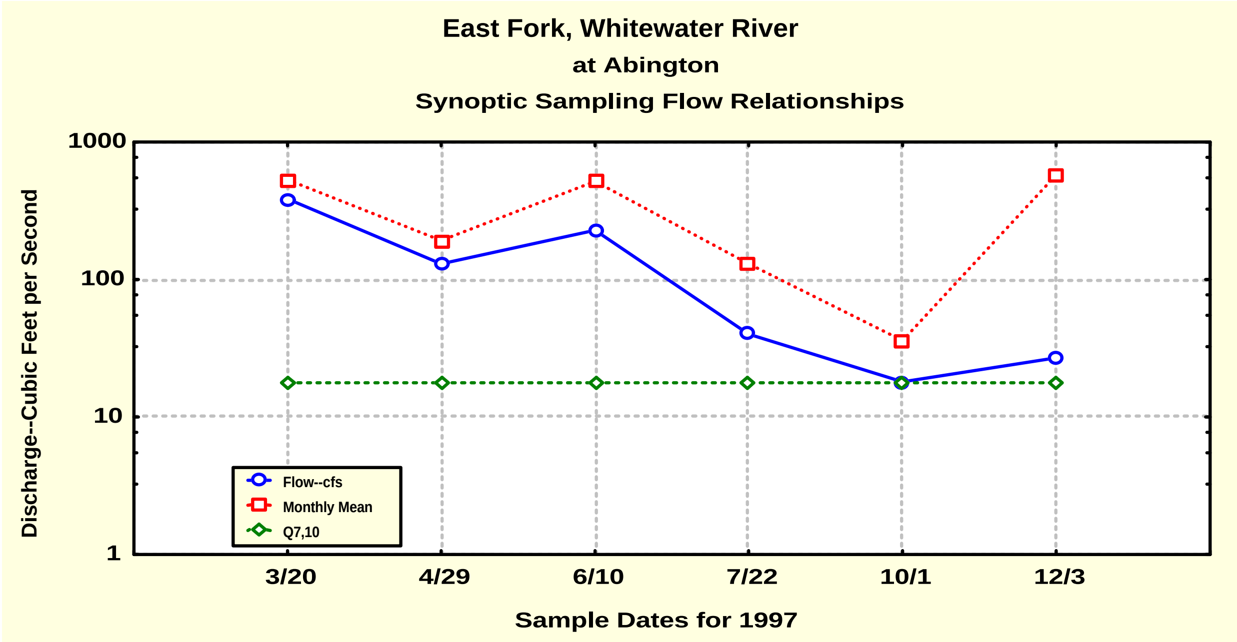


Figure III·5c



Results and Discussion of Suspended Solids Discharge

Pertinent flow and suspended solids data at the three selected gaging station sites for this study can be found by referencing Table III·1. Observation of suspended solids data from the three gaging station sampling sites did not always reveal a predictable pattern or direct correlation of flow to suspended solids levels for each site. This was particularly evident when comparing values for intermediate flow stages. Sometimes high suspended solids were observed at low flow stages and low suspended solids were found at high flow stages for a particular site. The only consistent exception was evident by comparing the extremely high flow suspended solids during the high flow sampling events in the spring and early summer with the low flow sampling events in late fall. Actual suspended solid values for each event are dependent upon timing compared with the rise or fall of the stream. High values will normally be obtained during an initial flush from surface runoff at the beginning of a rainfall event when the stream is rising. Relative lower values will be observed on the descending side of the hydrograph when a stream has crested or is falling and the influx of particulates from runoff has ceased.

Table III·1 Pertinent Flow and Suspended Solids Data

East Fork Whitewater River @ Abington - 33 years of record, drainage area of 200 mi^2

Date	Flow (cfs)	Monthly Mean (cfs)	Suspended Solid Concentration (mg/L)	Suspended Solid Loadings (tons/day)
3/20/97	387	378	6	6.26
4/29/97	130	385	4	1.4
6/10/97	228	187	7	4.3
7/22/97	40	163	7	.76
10/1/97	18.3	78	6	.29
12/3/97	27	292	4	.29
Annual Mean 230 cfs			$Q_{7,10}$ 18cfs	

Whitewater River @ Alpine - 80 years of record, drainage area of 529 mi^2

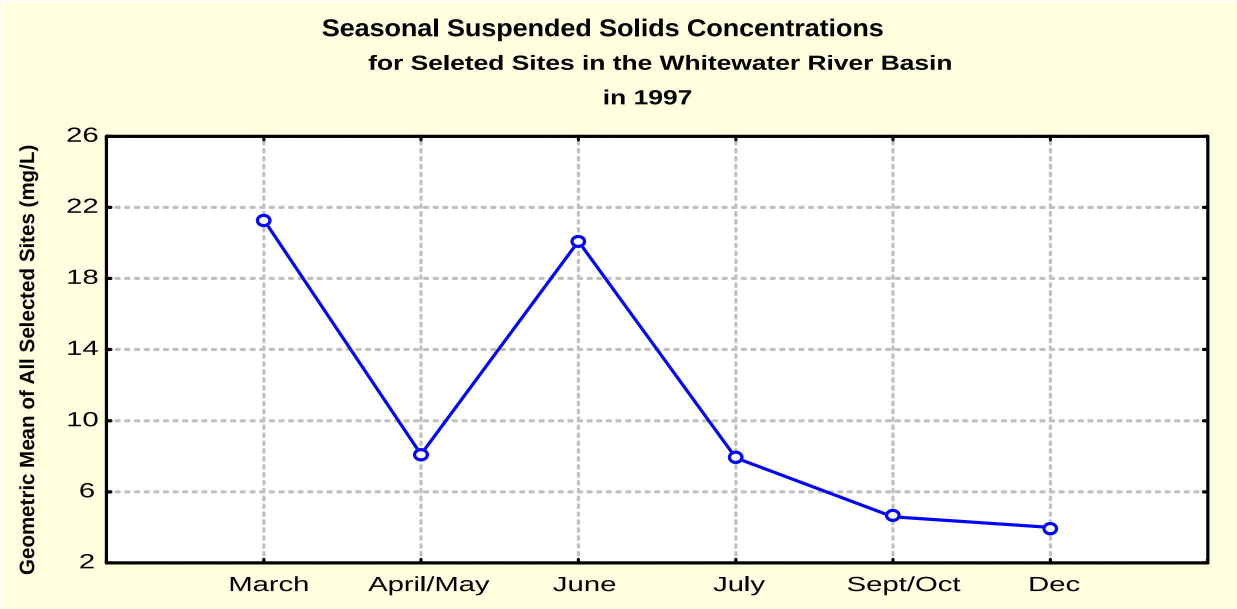
Date	Flow (cfs)	Monthly Mean (cfs)	Suspended Solid Concentration (mg/L)	Suspended Solid Loadings (tons/day)
3/18/97	1,150	1,015	49	151.9
5/1/97	377	95	33	33.5
6/12/97	750	66	48	97.1
7/24/97	276	51	10	7.44
9/29/97	124	25	4	1.35
12/3/97	196	76	4	2.11
Annual Mean 573 cfs			$Q_{7,10}$ 51 cfs	

Whitewater River @ Brookville - 54 years of record, drainage area of 1,224 mi^2

Date	Flow (cfs)	Monthly Mean (cfs)	Suspended Solid Concentration (mg/L)	Suspended Solid Loadings (tons/day)
3/20/97	1,672	2,296	33	148.8
4/29/97	561	2,171	4	6.1
6/10/97	5,965	1,208	24	386.1
7/22/97	364	756	7	6.87
10/1/97	59	470	4	.64
12/3/97	282	1,13	4	3.04
Annual Mean 1,312 cfs			$Q_{7,10}$ 102 cfs	

Analyzing the data collectively for all sites, suspended solid concentrations (mg/L) were evaluated on a seasonal basis. This was accomplished by calculating the geometric mean (used to negate the effect of outlying or high data points) of all three sites for each six sampling events during 1997 (Figure III·6). Results showed the early spring sampling event in March to have the highest geometric mean of 21.3 mg/L suspended solids. Alpine and Brookville sites showed their highest geometric mean values for this high flow stage event. The highest value observed was 49 mg/L at the Alpine site on March 18 during a high flow event. The low geometric mean occurred during the December sampling event. An extremely low suspended solids level of 4 mg/L was observed for all three sites for this last event in late fall and early winter.

Figure III·6



Suspended solids loading calculations showed the high levels for each site did not necessarily correspond to the high geometric mean concentrations found during the March sampling event (Figures III·7a through III·7c). An obvious exception occurred at the Brookville site where 386 tons/day of suspended solids were calculated for the June 10 sampling event, and that was well above the March loading of 148 tons/day. This was the highest loading of all sampling events, and was due to the extremely high stream flow of 5,965 cfs that was existent during the June sampling event. The lowest loadings for all sites were found to occur during the September/October sampling events when stream flow was at the lowest level for all selected sites. The singular lowest loading was 0.29 tons/day at the Abington site on October 10.

Figure III·7a

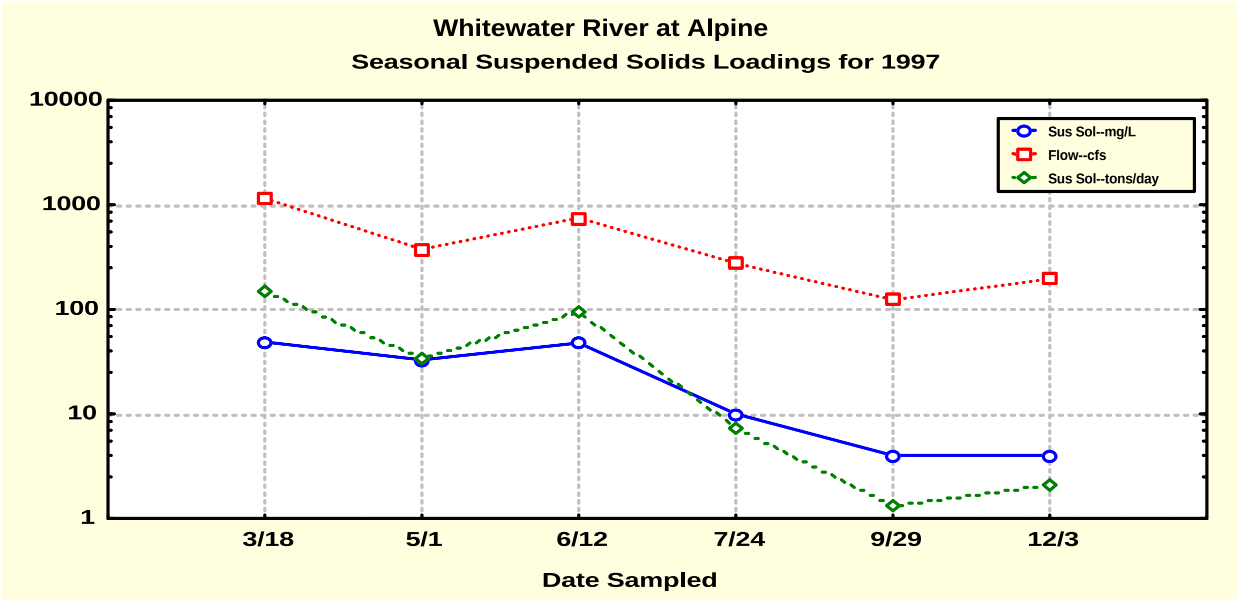


Figure III·7b

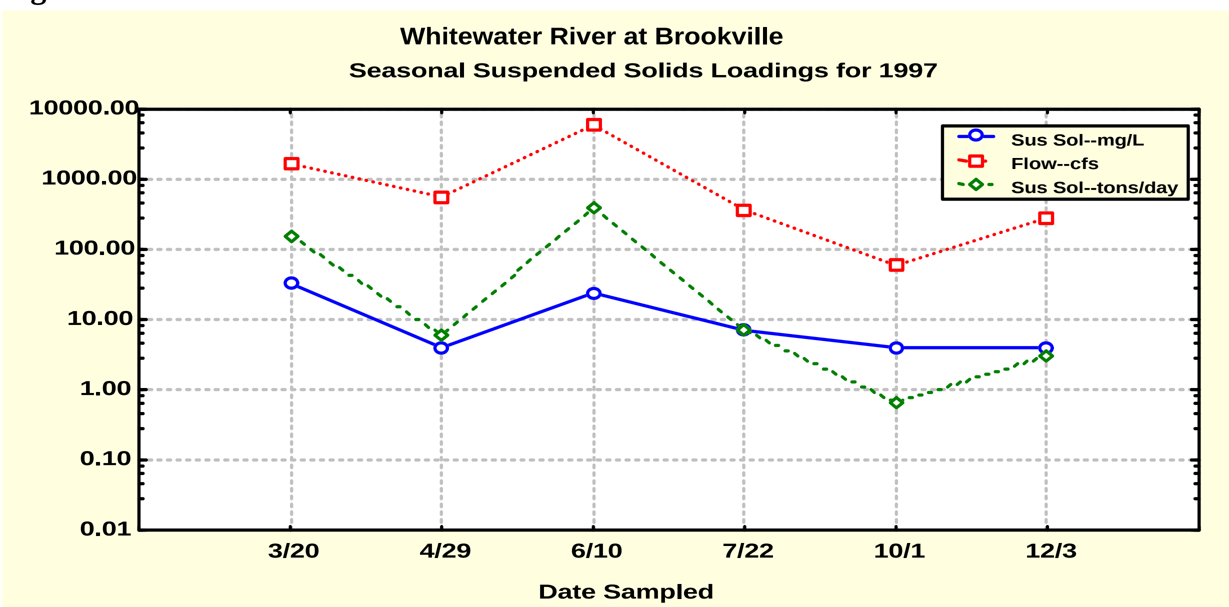
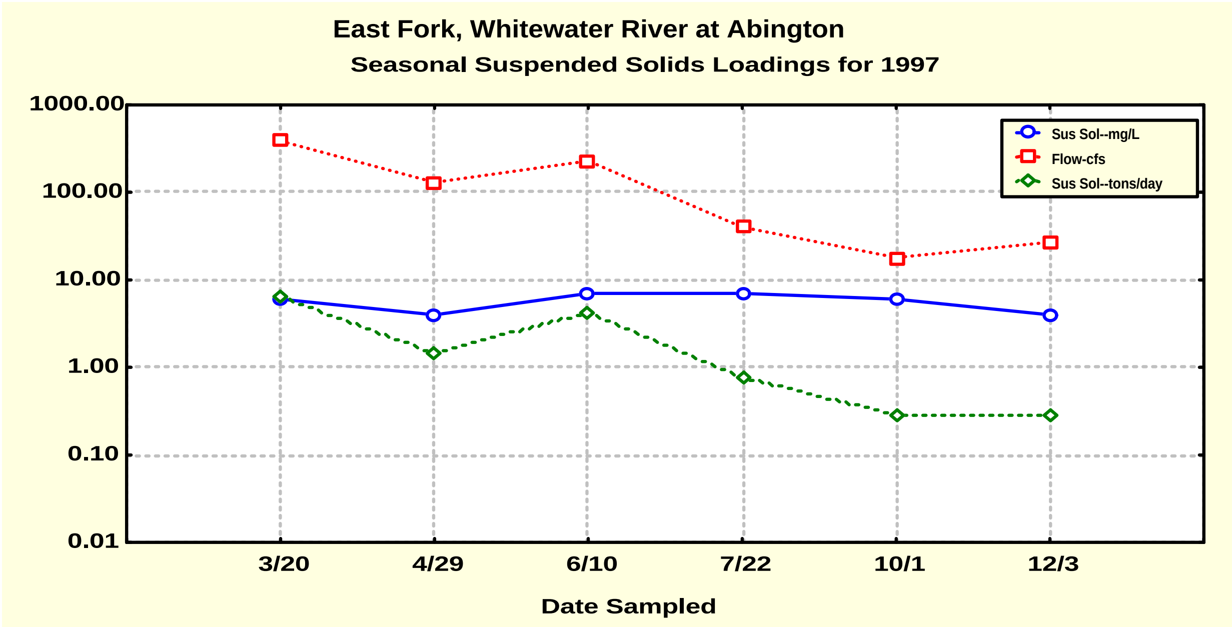


Figure III·7c



Spatial variations of suspended solids concentrations in the Whitewater River Basin were obtained by calculating geometric means of all six sampling events for each site. These determinations showed the high geometric mean occurred at the Alpine sampling site where a value of 15 mg/L was calculated. This exceeded the geometric mean concentrations further downstream at the Brookville site where only 8 mg/L was calculated. Correspondingly, the Alpine geometric mean loading (14.7 tons/day) for all sampling events exceeded the Brookville geometric mean loading (12.8 tons/day) although the Brookville site had consistently higher flow levels at the time of sampling. The Abington site on the East Fork Whitewater River only showed a geometric mean loading of 1.2 tons/day for the sampling events in 1997.

Summary and Conclusions

Suspended solid concentrations in milligrams per liter (mg/L) did not appear to have a direct correlation to flow levels in the Whitewater River Basin. Suspended solid levels at any particular site may be related to the time of rain events. Higher levels existed during the first flush shortly after a rain event began and started to runoff. On a seasonal basis, geometric mean concentrations of all sites were observed to be the highest during the spring sampling event in March when rain events were more prevalent and greater runoff was occurring basin wide. The calculated suspended solid loadings were the highest in March for two of the three selected sites. However, one notable exception was at Brookville where the highest loading occurred in June.

Spatially, the highest suspended solid concentrations and loadings in the Whitewater River Basin occurred at the Alpine site although the Brookville site is much further downstream and near the discharge point of the watershed. The Abington site showed the lowest concentrations of the selected gaging stations due to lower flows at this location.

IV Nutrients

by

Mark A Holdeman

Introduction

This section deals with chemical elements and compounds classified as nutrient parameters that were measured in the Whitewater River during the Synoptic Sampling Surveys in 1997. By looking at these parameters we can see where concentrations varied and where anomalies existed. These variations may indicate water quality problems.

General Explanation of Nutrient Parameters

The primary environmental concern, as related to nutrients in lakes and rivers, is eutrophication. This refers to excess levels of nutrients that can cause excessive algal growth, and can result in many problems within an aquatic system. Excessive algal growth not only causes significant diurnal fluctuations in water chemistry, but it can particularly be a problem when the excessive growth dies off and begins to decay. This can cause oxygen depletion in the water body and wide spread fish kills. The result is a decline of what would be considered a healthy water body system.

Plants are limited in growth by certain elements and chemical compounds. Carbon, nitrogen, phosphorus, and silicon are the major nutrients. These are known as macronutrients. Carbon and silicon are available in large amounts in the environment, and they are not limiting to plant growth. Therefore, nitrogen and phosphorus are the macronutrients of most concern (Allan 1996).

Total Kjeldahl Nitrogen (TKN), along with Total Phosphorus and Total Organic Carbon were selected as indicators for sampling. These parameters represent the nutrients of concern in the environment for the Surveys Section’s synoptic surveys. Total Kjeldahl Nitrogen, the first indicator selected, is the sum of organic nitrogen and ammonia as determined by analytical method. The method determines nitrogen in the trinegative state. It does not include nitrogen as azide, azine, azo, hydrazone, nitrate, nitrite, nitrile, nitro, nitroso, oxime, and semi-carbazone (APHA 1995, p 4-91).

The second indicator selected was Total Phosphorus. Phosphorus is mostly found as phosphate (completely oxidized phosphorus) in stream waters. It is not as abundant in the environment as nitrogen, and is usually the limiting factor for autotrophic growth in water (Hem 1985).

The third water quality indicator selected was Total Organic Carbon (TOC). This parameter is a more convenient, and direct expression of total organic content than Biochemical Oxygen Demand (BOD) or Chemical Oxygen Demand (COD), though it does not give the same information. Organic carbon in stream water consists of various organic compounds in different states of oxidation. Some organic carbon does not respond to the BOD or COD test and; therefore, makes those tests unsuitable for the measurement of organic carbon (APHA 1995, p 5-16).

Large rivers can receive a major amount of their organic carbon from the flood plain, especially during floods. This organic carbon can flow to lower reaches of the river and cause an increased heterotrophic bacterial population. This population consumes Dissolved Organic Carbon, that in turn provides food for higher trophic levels (Schlesinger 1991). Given this factor, TOC is a good nonpoint source pollution indicator.

Nitrate was added as an additional parameter to the 1997 Synoptic Sampling Surveys. It is listed in the State's Water Quality Standards. Nitrate in drinking water at high levels is of health concern for humans. Most nitrate is probably from anthropogenic sources and most of that amount is from agricultural origins. For the purpose of this report Nitrate refers to Nitrate+Nitrite/N, USEPA Test Method 353. The drinking water standard at the point of a water intake is 10 mg/L.

Sources of Contamination

Many sources of nitrogen and phosphorus contribute to the water quality of the Whitewater River Basin. These include municipal sewage, industrial discharge, atmospheric deposition, commercial fertilizer, and farm-animal manure.

Inferring the importance of nutrients in running waters solely from the levels of their concentrations is difficult, but they are useful in characterizing the productivity of riverine ecosystems. The water chemistry of rivers is quite variable, especially in smaller water bodies due to location, season, geology, rainfall, and of course human activity (Allan 1996).

Methods and Materials

For a discussion concerning sampling and data interpretation methods regarding the data presented here, see Chapter II. Appendix B, Figures B·1 through B·4, and Table IV·1, show data from the main stem of the Whitewater River grouped into one set, per each parameter, to give the overall ranges for each parameter. A basic statistical analysis is presented in Appendix B, Figures B·5 through B·8, using box plots to show the ranges from up to down stream for the main stem sites on the East Fork Whitewater River. Appendix B, Figures B·9 through B·12, show data in box plots from each tributary stream comparing one with the other.

Results and Discussion

We viewed these data from upstream to downstream noticing changes in the water quality of the main stem. We also looked at the variation in levels of nutrient concentrations in the tributaries, which should suggest troubled areas. Given the limited amount of data collected in this project thus far, it is beyond the scope of this report to make interpretations concerning trends over time. This is one goal of the Office of Water Management's new Surface Water Quality Monitoring Strategy 1996-2000 (IDEM 1996), and can be accomplished as the sampling program continues in future years.

Concentrations in the Whitewater River Main Stem

Phosphorous data on the main stem of the Whitewater River (Table IV·1, and Appendix B, Figure B·1) ranged from a minimum of 0.03 mg/L to a maximum of 0.19 mg/L. The overall median values were below 0.08 mg/L. This is low compared with the East Fork White River Basin that was also sampled in 1997.

Total Kjeldahl Nitrogen values from this set of data on the main stem of the Whitewater River (Appendix B, Figure B·2) show a similar pattern. A minimum of 0.05 mg/L and a maximum of 0.99 mg/L was measured. Median values for each site’s data set did not show much variation.

Total Organic Carbon ranged from a minimum of 0.05 mg/L to a maximum of 3.80 mg/L (Appendix B, Figure B·3). The ranges also appear low when compared with the East Fork White River. Two sites on the main stem, 89-01, and 89-03, had median values above 2.0 mg/L, though these values were lower than median values for the East Fork White River (Appendix B, Figure B·6).

Nitrate-Nitrite values for the main stem ranged from a minimum of 1.80 mg/L to a maximum of 4.60 mg/L, with a median value of 3.0 mg/L (Appendix B, Figure B·4). These values are higher than those found in the East Fork White River. The highest values were noted around the Connersville area.

Table IV·1 Whitewater River, main stem sites combined as one set
Except for sample size, all units expressed in milligrams per liter.

	Nitrate + Nitrite /N	Total Phosphorus	Total Kjeldahl Nitrogen	Total Organic Carbon
Valid N	42.00	42.00	42.00	42.00
Mean	3.07	0.07	0.46	2.00
Confidence -95.000%	2.86	0.05	0.39	1.78
Confidence 0.95	3.28	0.08	0.53	2.21
Median	3.00	0.06	0.47	2.00
Sum	129.00	2.80	19.39	83.80
Minimum	1.80	0.03	0.05	0.50
Maximum	4.60	0.19	0.99	3.80
Lower Quartile	2.50	0.04	0.39	1.60
Upper Quartile	3.60	0.09	0.60	2.20
Range	2.80	0.17	0.94	3.30
Quartile Range	1.10	0.05	0.21	0.60
Variance	0.45	0.00	0.05	0.46
Std Deviation	0.67	0.04	0.22	0.68
Standard Error	0.10	0.01	0.03	0.10
Skewness	0.28	1.39	-0.23	0.69
Std Error Skewness	0.37	0.37	0.37	0.37
Kurtosis	-0.16	1.80	0.03	0.59
Std Error Kurtosis	0.72	0.72	0.72	0.72

Concentrations in the East Fork Whitewater River

Phosphorous data from the East Fork of the Whitewater River (Table IV·2, and Appendix B, Figure B·5) ranged from a minimum of 0.03 mg/L to a maximum of 0.35 mg/L. Sites below Richmond and at Abington were slightly above 0.08 mg/L, the median value of main stem data set.

Total Kjeldahl Nitrogen values from the East Fork Whitewater River resulted in a minimum of 0.5 mg/L and a maximum of 1.20 mg/L (Appendix B, Figure B·6). Median values for sites below Richmond were above the fiftieth percentile of the data set of the main stem sites.

Table IV·2 East Fork of the Whitewater River, main stem sites combined as one set
Except for sample size, all units expressed in milligrams per liter.

	Nitrate + Nitrite/N	Total Phosphorus	Total Kjeldahl Nitrogen	Total Organic Carbon
Valid N	31	31	31	31
Mean	3.23	0.08	0.50	2.79
Confidence -95.000%	2.57	0.06	0.42	2.55
Confidence 0.95	3.89	0.10	0.59	3.03
Median	3.10	0.08	0.51	2.80
Sum	100.12	2.45	15.57	86.50
Minimum	0.53	0.03	0.05	1.60
Maximum	8.80	0.35	1.20	4.00
Lower Quartile	1.70	0.04	0.35	2.30
Upper Quartile	4.40	0.10	0.64	3.30
Range	8.27	0.33	1.15	2.40
Quartile Range	2.70	0.06	0.29	1.00
Variance	3.27	0.00	0.05	0.44
Std Deviation	1.81	0.06	0.23	0.66
Standard Error	0.32	0.01	0.04	0.12
Skewness	0.98	3.20	0.64	0.27
Std Error Skewness	0.42	0.42	0.42	0.42
Kurtosis	1.55	13.85	1.84	-0.74
Std Error Kurtosis	0.82	0.82	0.82	0.82

Total Organic Carbon from this area ranged from a minimum of 1.6 mg/L to a maximum of 4.0 mg/L (Appendix B, Figure B·7). The ranges show a distinct increase in the area beginning downstream of Richmond. Also, the site below Brookville Lake showed values above the median of the East Fork Whitewater River data set.

Nitrate-Nitrite values for the East Fork Whitewater River ranged from a minimum of 0.53 mg/L to a maximum of 8.80 mg/L, with a median value of 3.10 mg/L (Appendix B, Figure B·8). These values are higher than those found in the East Fork White River, also sampled in 1997. The highest values were noted south of Richmond and at the Abington site.

Nutrient Concentrations in the Tributaries to the Whitewater River

When reviewing the nutrient data, all tributary streams of the Whitewater River were combined into a single data set for each parameter to get the overall ranges of values shown in Table IV·3. Values were then selected at or above the median of this data set to compare with the individual tributary stream site values. Tributary stream values that were above the selected values or medians of the combined data are considered as possible problem areas. A review of the box plots of the nutrient data collected from tributaries of the Whitewater River gave the following results:

Phosphorus data showed that no median values for any site data set were significantly above the median value (0.04 mg/L) for all tributary sites combine in this basin. (Appendix B, Figure B·9).

- Total Kjeldahl Nitrogen, no tributaries of the Whitewater River were found to have median values significantly above 0.5 mg/L. (Appendix B, Figure B·10).

- Total Organic Carbon data sets displayed in the box plots of these tributaries that were found to have median values above 2.70 mg/L were: Pipe Creek (88-05), and Blue Creek (89-02). (Appendix B, Figure B·11).

- Nitrate-Nitrite values for tributaries of the Whitewater River ranged from a minimum of 0.05 mg/L to a maximum of 5.80 mg/L, with a median value of 2.60 mg/L. Sampling sites with median values above the median of the entire tributary data set combined were: Martindale Creek 87-02, Greensfork 87-03, and Nolands Fork 87-04 (Appendix B, Figure B·12).

Table IV·3 Whitewater River Tributaries, sites combined as one data set
Except for sample size, all units expressed in milligrams per liter.

		Nitrate + Nitrite	Total Phosphorus	Total Kjeldahl Nitrogen	Total Organic Carbon
	Valid N	42	42	42	42
	Mean	2.45	0.07	0.63	2.70
Confidence	-95.000%	1.93	0.04	0.43	2.29
Confidence	0.95	2.97	0.11	0.83	3.11
	Median	2.60	0.04	0.50	2.70
	Sum	102.93	3.13	26.48	113.50
	Minimum	0.05	0.03	0.05	0.50
	Maximum	5.80	0.69	4.20	7.90
Lower	Quartile	0.74	0.03	0.37	1.80
Upper	Quartile	3.60	0.08	0.73	3.00
	Range	5.75	0.67	4.15	7.40
Quartile	Range	2.86	0.05	0.36	1.20
	Variance	2.82	0.01	0.41	1.72
	Std Deviation	1.68	0.11	0.64	1.31
Standard	Error	0.26	0.02	0.10	0.20
	Skewness	0.07	4.55	4.39	1.44
Std Error	Skewness	0.37	0.37	0.37	0.37
	Kurtosis	-1.14	24.10	23.67	4.85
Std Error	Kurtosis	0.72	0.72	0.72	0.72

Relationship of Flow Levels to Concentrations

Graphs showing selected sampling sites in relationship to flow are presented in Appendix B, Figures B·13 through B·24. Concentrations were plotted against flow as measured by USGS gaging stations. No overall trend is evident for the nutrients sampled in relation to flow in the main stem Whitewater River or in the East Fork Whitewater River. There is mixed evidence of increased nutrient values in the upstream areas during higher flow levels indicated in this data. This could show some nonpoint source pollution problems.

Summary and Conclusions

This chapter presents the nutrient data collected during the 1997 Synoptic Sampling Surveys of the Whitewater River. A general explanation of each parameter and reasons for its selection is given. Basic statistics of each parameter are presented in graph and table form for the main stem of the Whitewater River, East Fork Whitewater River and their tributaries. Sites and geographical areas of concern are listed.

The following conclusions about these nutrients can be drawn:

- The sampling sites of most concern, based on the data collected for these surveys, are in the Whitewater River around the Connersville area. Also, areas in the East Fork Whitewater River downstream of Richmond and near Abington area were found to have slightly elevated values of nitrate. Martindale Creek, Greens Fork and Nolands Fork were tributaries with elevated nitrate values. The highest median values of the data set for nitrate occurred in these areas. Although the water quality standard of 10 mg/L for this parameter was not exceeded, higher than median values show that management improvements could probably be made to avoid any further decline in water quality. Blue Creek had high Total Organic Carbon values.

- These increases are probably due to nonpoint sources associated with urban, suburban, and agricultural land runoff. Some comparisons of flow measured at selected USGS gaging stations in relationship to nutrient concentrations are presented in this chapter.

- As flow levels increased in the up stream tributaries, some nutrient parameter levels increased showing possible nonpoint source runoff input in the upstream area. The lower reaches of the main stem Whitewater River and the East Fork Whitewater River did not demonstrate the same dynamics probably due to dilution.

It is not possible to tell precisely what caused these higher nutrient concentration levels in the data sets given the broad nature of this sampling, but the following recommendations can be made:

- Further examination of the data, and more precise targeted sampling are needed because of the generally higher nutrient levels found so that areas of concern may be analyzed in more depth.

- All tributaries exhibiting elevated nitrate concentration values should be examined for specific point and nonpoint source problems. This should be done according to the Office of Water Management's Surface Water Quality Monitoring Strategy 1996-2000 (IDEM 1996). This strategy was updated in 1998. Further sampling may be warranted in these tributaries as well.

- A further examination of flow hydrographs should be carried out, to see what effects the overall loading relationship is to the main stem from its tributaries regarding nutrients.

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V Heavy Metals

by

Timothy J Beckman and Sammy C Gibson

Introduction

Heavy metals can be introduced into the water from both natural and human activities. Metals can be introduced into surface water from soil and crustal erosion, industrial and municipal wastewater effluents, and runoff resulting from land use activities such as agriculture, silviculture, and mining. Once metals are introduced into the water, several processes may occur depending on the type of metal released. Heavy metals may be dissolved in water, become volatilized to the air, or become attached to suspended solids and then deposited in streambed sediment.

Humans and other living organisms uptake metal compounds through water and food. Some metals, including iron, are important in the metabolic process of all living organisms, but become toxic at higher concentrations (Garbarino and others 1995). Some heavy metals, including copper and zinc, have been linked to beneficial human growth, development, and reproduction (Vahrenkamp 1979; Friberg and others 1979). Conversely, several heavy metals, including lead, are highly toxic even at low concentrations and can accumulate in body tissue over long periods (Garbarino and others 1995).

Nineteen (19) synoptic sites were sampled and analyzed for heavy metals in the Whitewater River Basin on six different dates during 1997. Sampling times were scheduled to provide data representative of seasonal ambient variations. Nine (9) heavy metals were analyzed in the waters from the basin as Total Recoverable, namely; arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel and zinc. Streambed sediments were not analyzed for heavy metals during this study.

Data Presentation

One method for displaying data is box-whisker plots. The box portion of the plot encloses the 25th to 75th percentile (the center portion of the data). This range is called the interquartile range. The median (50th percentile) is represented by a small square within the box. Data values less than the 25th percentile and greater than the 75th percentile are represented by horizontal lines called whiskers extending from either side of the box. These whiskers extend up to 1.5 times the interquartile range from either side of the box. Data points that are greater than 1.5 times the interquartile range, but less than three times the interquartile range from either side of the box are considered outliers and are represented with a small circle. Data points that are more than three times the interquartile range from either side of the box are considered extremes and are represented as an asterisk (StatSoft Inc 1998). The box plots are used in this document to display data within smaller divisions of the basin.

Another method for displaying data is a histogram. A histogram divides a population into groups by numeric value. These groups are represented on the x-axis. Each group is defined by two numbers, a lower number to the left and an upper value to the right. The rounded bracket on the left (the exclusive bracket) shows the group does not include the value while the squared bracket to the right (the inclusive bracket) shows the group includes this value. The number of observations in each group is shown by the height of each bar in the histogram. Further, a percentage that each group contains of the entire population is found above each bar. A normal curve is overlaid on the histogram to show how the data approximate a normal distribution. The apex of this curve is the mean of the population (StatSoft Inc 1998). Histograms are used in this document to display ranges of data for the basin as a whole.

Discussion and Results

Toxicity of most heavy metals to aquatic life depends on both the metal concentration and the hardness (as calcium carbonate $CaCO_3$) present in the water. As hardness decreases and metal concentrations increase, toxicity increases. Table V·1 lists the State of Indiana water quality criteria, at various hardness levels, for selected metals analyzed in the Whitewater River Basin study.

Table V·1 Metals Criteria for the Protection of Aquatic Life

The maximum is expressed as the Acute Aquatic Criterion (AAC). The Chronic Aquatic Criterion (CAC) is generally lower than the AAC, but is established as a 4-day average exposure limit.

Hardness	Cadmium		Copper		Lead		Nickel		Zinc	
as $CaCO_3$	CAC	AAC	CAC	AAC	CAC	AAC	CAC	AAC	CAC	AAC
50	0.7	1.8	7	9	1.3	34	88	789	59	65
100	1.1	3.9	12	18	3.2	82	100	1418	97	107
200	2.0	8.6	21	34	7.7	197	100	2549	191	211
250	2.3	11.0	26	42	10.2	262	100	3079	230	254
300	2.7	13.5	30	50	12.9	331	100	3592	269	297

[Units–Hardness–milligrams per liter, Total Recoverable metals–micrograms per liter] Source: Title 327 IAC 2-1-6.

One hundred-twenty individual samples (including duplicates) were analyzed for each of the nine metals tested in the East Fork Whitewater River Basin study. This is a cumulative total of 1,080 discrete tests. Table V·2 lists the water quality criteria violations detected. The listed aquatic life criterion is based on the hardness value for each sample group.

Table V·2 East Fork Whitewater River Basin--Water Quality Standards Violations--Total Recoverable Metals

Site	Stream	Location	Date 1997	Lab # DA	Metal Fg/L	Crit. Fg/L
88-01	Williams Creek	Fayette CR 225 S, near Connersville	3-18	10104	Lead 27.5	**CAC** 15.7
87-01	Whitewater River	Jerry Meyers Road, south of Hagerstown	12-04	10993	Cadmium 9.0	**AAC** 7.6

A violation for Total Lead was detected in a sample collected during a heavy flood condition. All metals analyzed from this sample, except cadmium and mercury, were significantly above detection limits but did not exceed appropriate criteria. Those values are represented by asterisks on the box plots for the West Fork Whitewater River and tributaries as presented in Figures V·1 and V·2. One sample showed a total suspended solids result of 970 milligrams per liter, and that suggests high water and soil suspension levels. Stream flow was 255 cubic feet per second at the time this sample was collected. Flows measured during other sampling events at this site averaged 20 cubic feet per second.

The Total Cadmium sample that was above the Water Quality Standard was likely an anomaly. This parameter is usually associated with metal working operations, specifically plating. No other metals that are normally expected in plating wastes were detected in the sample.

Summary and Conclusions

The low percentage of water quality criteria violations suggest that the waters of the Whitewater River Basin are not significantly impaired by the presence of heavy metals. Further protection of aquatic life is provided by the natural background hardness values of the waters within the basin. The average hardness value for all samples collected within the basin was 300 milligrams per liter (as $CaCO_3$) and the median was 320 milligrams per liter. Further study into the effects of heavy suspended sediment compared with total recoverable metals detection may be in order.

The box plots for individual watersheds displaying total copper, total lead, and total zinc data are provided in Appendix C. These three parameters were chosen because they are traditionally found in significant concentrations in Indiana waterbodies. Histograms for all parameters except iron and mercury are included to gain a basin-wide perspective. Total iron was not plotted because no current water quality criteria have been established for assessment; mercury was not detected in the basin. Sampling site locations within the box plots are organized generally up to down stream via the main stem in each watershed.

VI Alkalinity, Hardness, Sulfate, Chloride, and Dissolved Solids

by

Carl C Christensen

Introduction

This report examines five general chemistry parameters evaluated during the 1997 synoptic study of the Whitewater River Basin. These five parameters were:

- alkalinity, the water's capacity to neutralized acid (APHA 1995)
- hardness, the sum of magnesium and calcium ion concentrations expressed as carbonate in milligrams per liter (APHA 1995)
- sulfate, SO_4^{2-}
- chloride, Cl^-
- dissolved solids, the portion of solids filterable through a standard glass fiber filter (APHA 1995)

This report examines that data to determine:

- The shape, central tendency, and range of the data for the various chemicals
- How the stations compared with each other from up to down stream and across the basin
- If and where surface water quality standards were violated

Methods

Summary Statistics

The data from the 1997 synoptic study of the Whitewater River Basin was downloaded into Statistica (StatSoft Inc 1998), a statistical analysis program. Data observed to be below the detection limit was arbitrarily assigned a value of the detection limit. The data from all of the stations for each water chemistry parameter were compiled into sets. Batteries of statistics were calculated for each of these compiled sets to determine basin wide statistics. The data were then examined graphically by using box-whisker plots and histograms.

Graphics Methods

One method for displaying data is a histogram. A histogram divides a population into groups by numeric value. These groups are represented on the x-axis. Each group is defined by two numbers, a lower number to the left and an upper value to the right. The rounded bracket on the left (the exclusive bracket) shows the group does not include the value while the squared bracket to the right (the inclusive bracket) shows the group includes this value. The number of observations in each group is shown by the height of each bar in the histogram. A normal curve is overlaid on the histogram to show how the data approximates a normal distribution. The apex of this curve is the mean of the population.

Another method for displaying data is box-whisker plots. The box portion of the plot encloses the 25th to 75th percentile (the center portion of the data). This range is called the quartile range. The median (50th percentile) is represented by a small square within the box. Data values less than the 25th percentile and greater than the 75th percentile are represented by horizontal lines called whiskers extending from either side of the box. These whiskers extend up to 1.5 times the quartile range from either side of the box. Data points that are greater than 1.5 times the quartile range, but less than three times the quartile range from either side of the box are considered outliers and are represented with a small circle. Data points that are more than three times the quartile range from either side of the box are considered extremes and are represented as an asterisk.

Surface Water Quality Standards

The data were examined to decide if and where surface water quality violations occurred. The database was searched to make these determinations based on the standards listed in the Indiana Administrative Code.

Results and Discussion

Statistical Summary

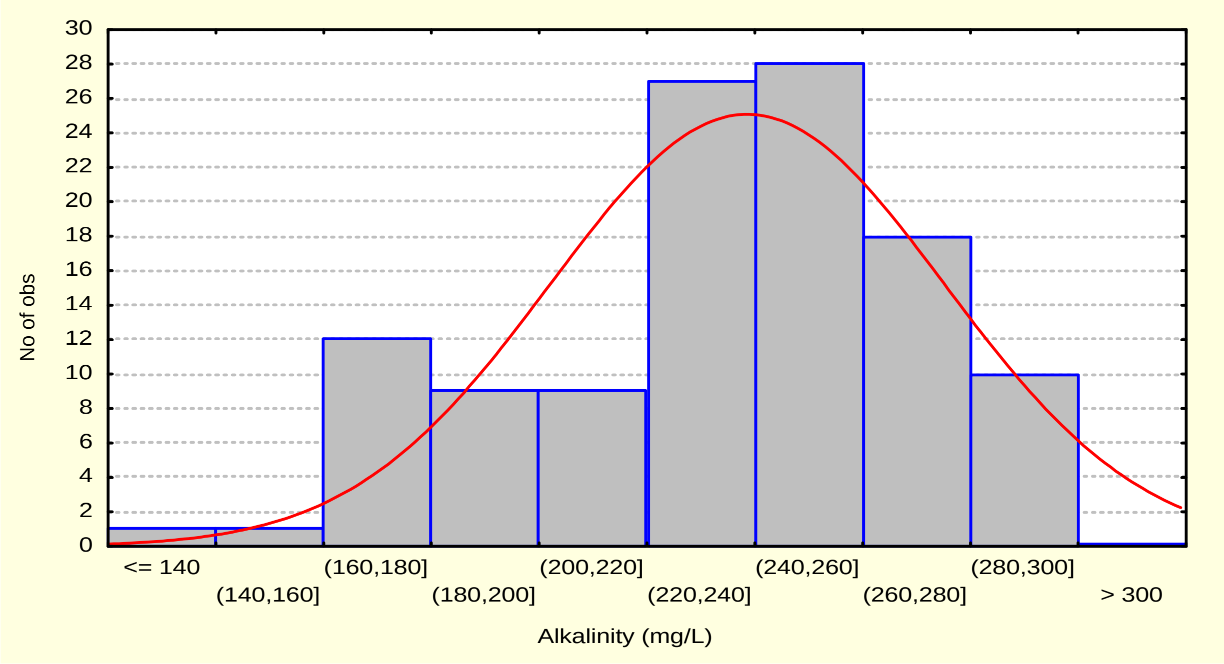
A useful method of data analysis for large data sets is to compute summary statistics. Five general chemistry parameters were analyzed using these statistical methods. Table VI·1 lists the general chemistry parameters and their statistical results. These statistics create a picture of the shape, central tendency, and the most typical concentrations observed in the study.

Table VI•1 Statistical Summary of the Whitewater River Basin

	Alkalinity	Suspended Solids	Dissolved Solids	Sulfate	Hardness	Chloride
Valid N	115	114	114	115	115	115
Mean	239	20.3	362	41.6	296	26.8
-95.000% Confidence Interval	232	3.32	349	39.5	283	23.6
+95.000% Confidence Interval	245	37.3	377	43.7	309	29.9
Median	240	4	360	39	310	22
Sum	27440	2314	41340	4784	34071	3082
Minimum	140	4	240	25	81	7.3
Maximum	300	970	700	90	410	120
Lower Quartile	220	4	310	35	240	19
Upper Quartile	260	11	400	44	350	29
Range	160	966	460	65	329	113
Quartile Range	40	7	90	9	110	10
Variance	1338	8373	5659	125	4895	300
Standard Deviance	36.6	91.5	75.2	11.2	69.9	17.3
Error	3.41	8.57	7.05	1.05	6.52	1.61
Skewness	-0.58	10.1	1.19	1.98	-0.82	2.80
Kurtosis	-0.27	105	3.52	4.75	-0.026	9.65

The mean and the median are often used to describe the most typical value for a given chemical. Ideally, the median value should approximate the mean. Anomalous activities in the watershed such as rainfall events can produce outliers. These outliers can elevate the concentration of the water chemistry and move the mean away from the median. When a chemical parameter has a skewness that is close to zero, either positive or negative, the data are considered evenly distributed on either side of the mean. The alkalinity data are an excellent example of where the mean is approximated well by the median, and the data is evenly distributed on either side of the mean (see Figure VI·1).

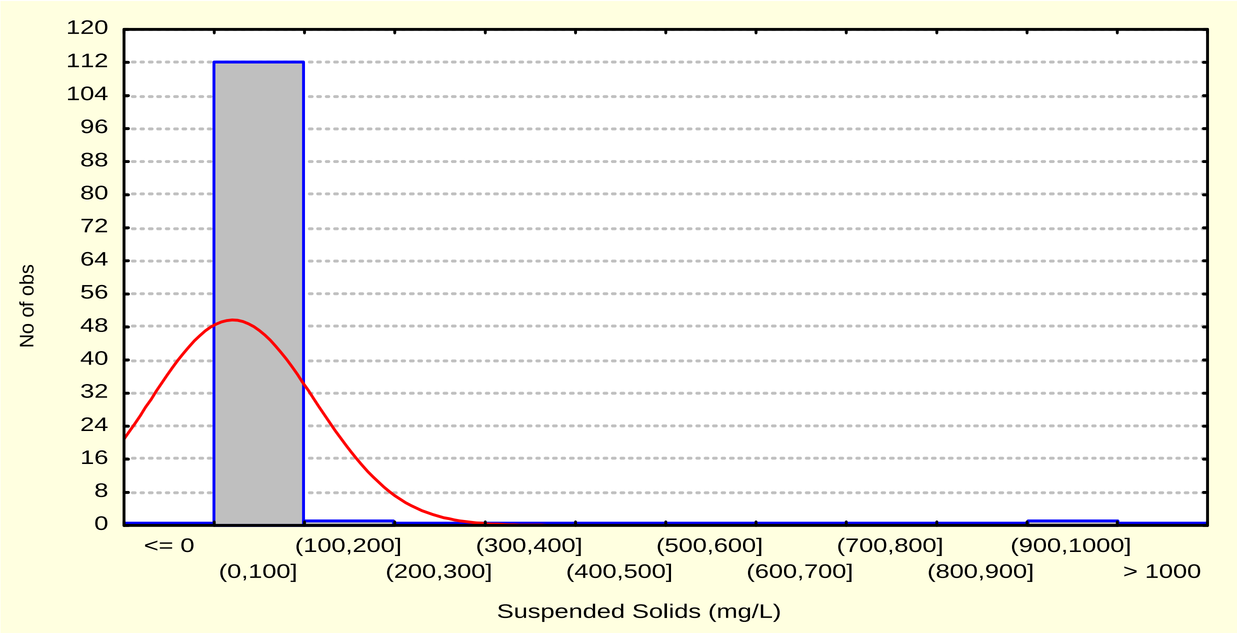
Figure VI·1 Alkalinity



The median observation for the basin's alkalinity was 240 mg/L and the mean (the apex of the normal distribution curve) was 238 mg/L. These observations can also be used to estimate the true population's mean. The mean of the true population is determined by the 95% confidence interval. This interval denotes where the true population mean lies with 95% confidence. For example, the 95% confidence interval for alkalinity ranges from 232 mg/L to 245 mg/L.

Sometimes, the median does not approximate the mean. Suspended solids had the greatest difference between the mean and the median. The skewness was the largest at 10.09 (see Figure VI·2).

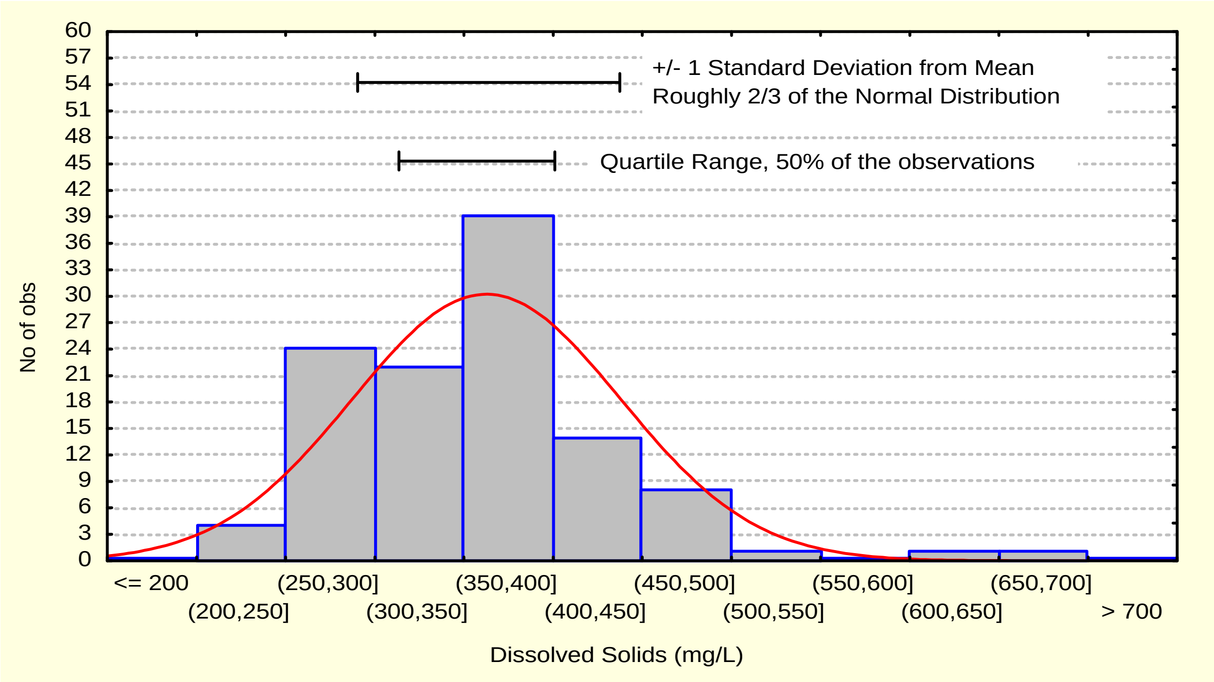
Figure VI·2 Suspended Solids



The large skewness was caused by outliers greater than 100 mg/L. These outliers elevated the mean to 20.3 mg/L. This was over a fivefold difference from the median (4 mg/L). For chemical parameters such as these, the median is a much better metric for describing the most common chemical concentration.

The statistics can also be used to describe the most typical range of values observed within the basin. The standard deviation and the quartile range are good statistics for approximating this. When a distribution approximates a normal shape, roughly 2/3 of the observations should be within one standard deviation of the mean. The quartile range is more flexible, because the shape of the data distribution is not important. This range is bounded by the upper and lower quartile. Despite the distribution, 50% of the observations are in the quartile range. Figure VI·3 graphically shows these concepts.

Figure VI·3 Dissolved Solids



Sampling Station Comparisons

Box-whisker plots were used to compare the relative range of water chemistry found at each station. Stations on each of the plots are generally up to down stream. Stations that were directly on the East Fork Whitewater River and the Whitewater River are denoted on the plots. Additionally, the locations of the Brookville Reservoir and of the confluence of the East Fork Whitewater River to the Whitewater River are noted (see Figures VI·4 through VI·8).

Figure VI·4 Alkalinity

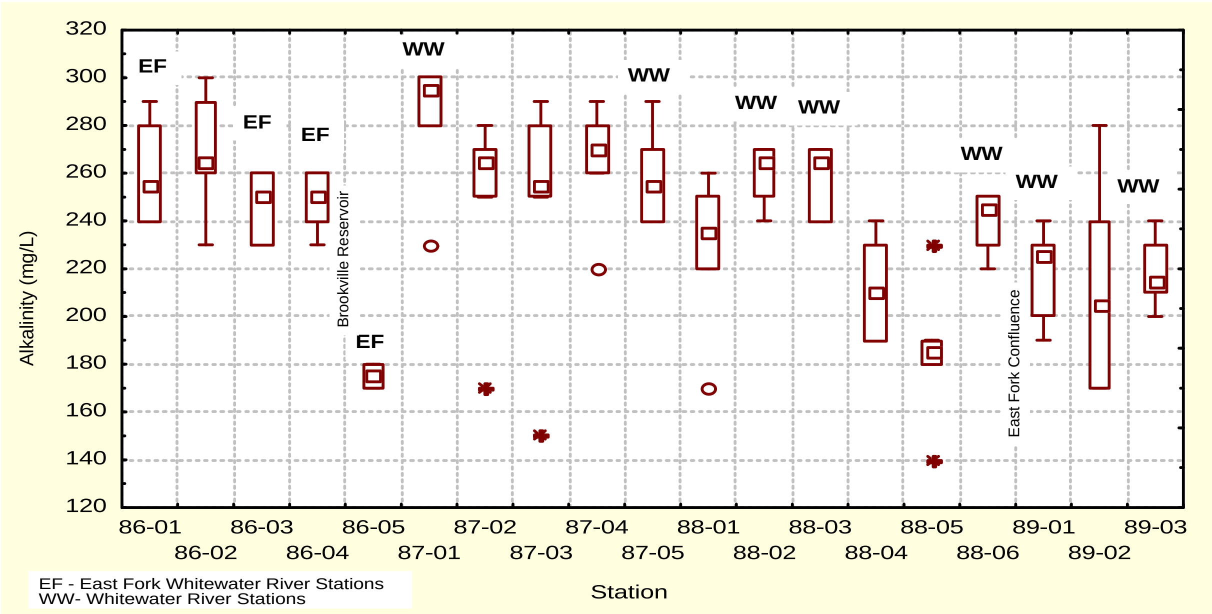


Figure VI·5 Hardness

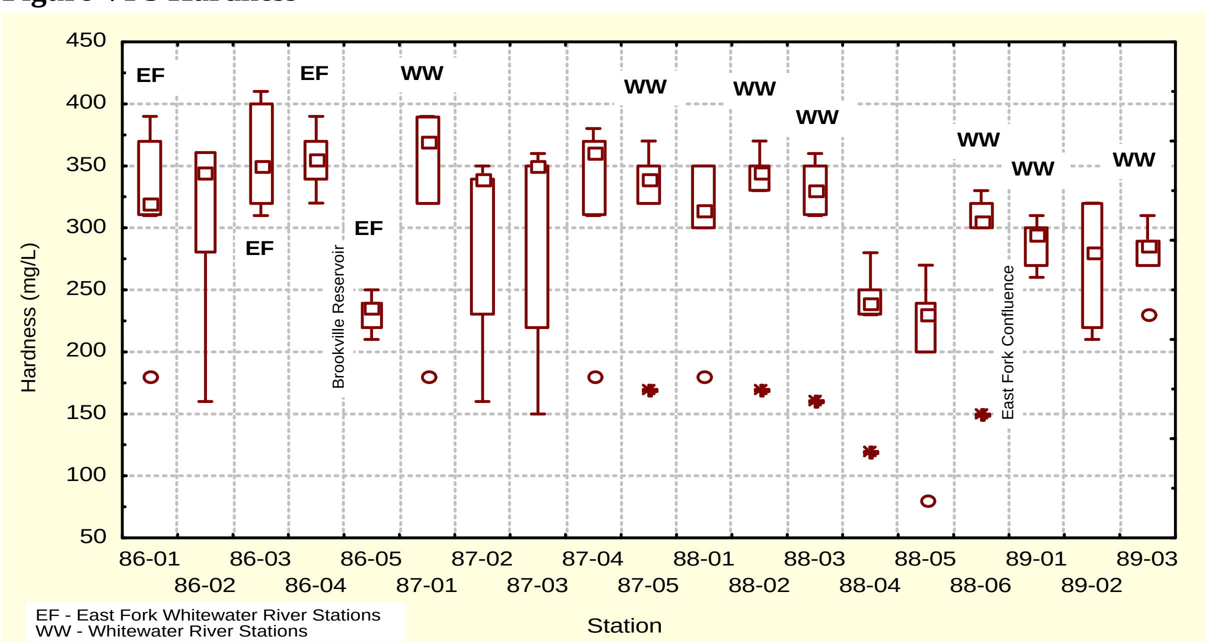


Figure VI·6 Sulfate

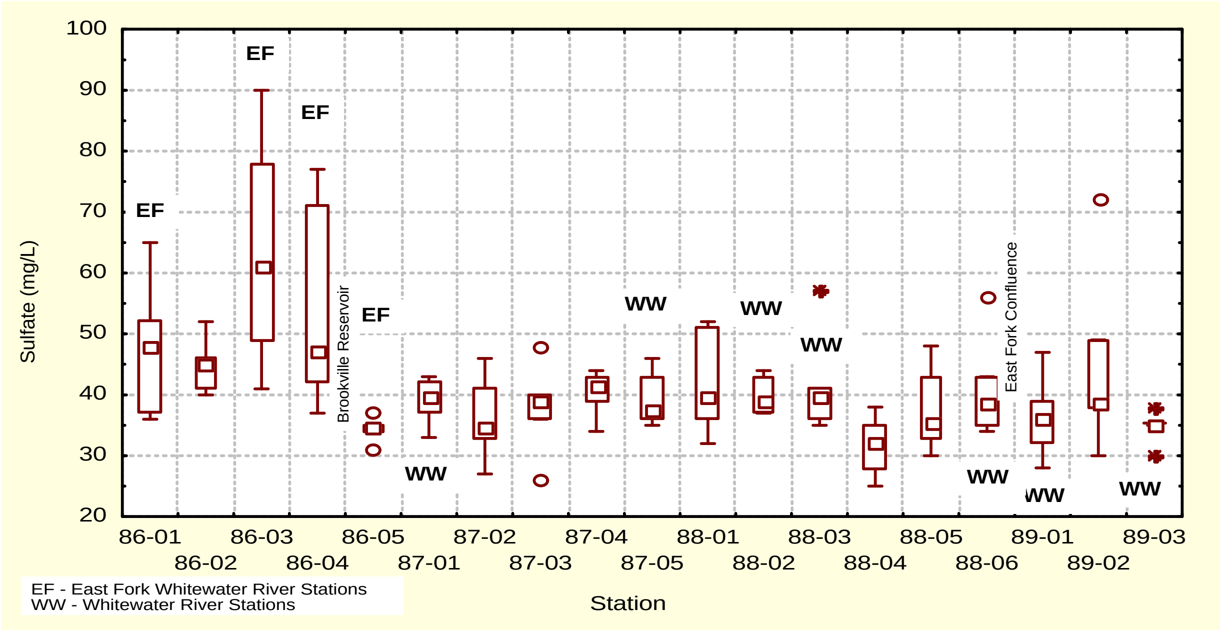


Figure VI·7 Chloride

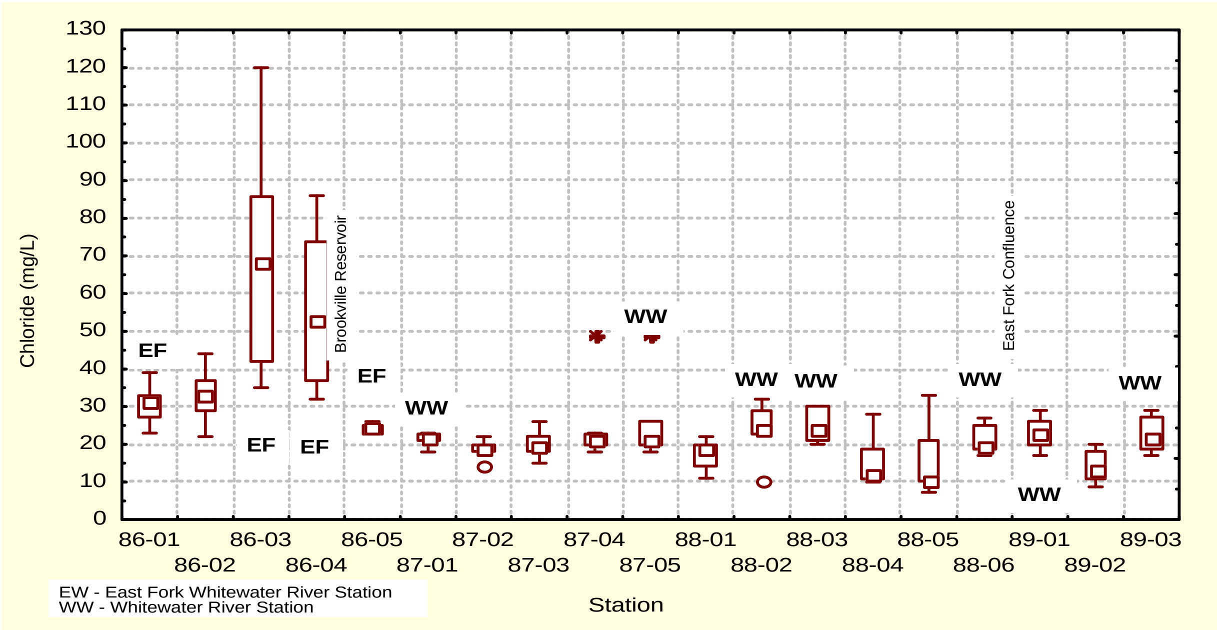
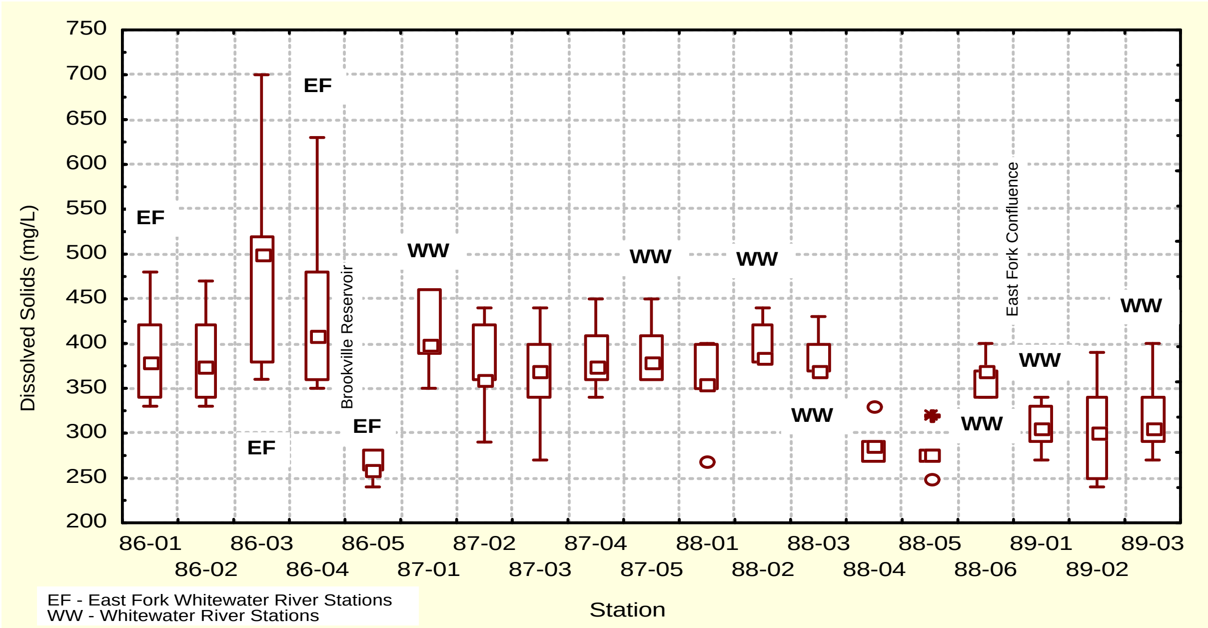


Figure VI·8 Dissolved Solids



Examination of these box-whisker plots shows the large impact of the Brookville Reservoir on the East Fork Whitewater River's chemistry. All of the water chemistry parameters decreased significantly from station 86-04 to 86-05. In each case, the quartile range for 86-04 did not overlap the quartile range for 86-05. The obvious reason for this was dilution of the chemistry from the large volume of water in the reservoir. The dilution of this large volume of water further created a very small range of observations found at 86-05.

Dilution of this water in the East Fork Whitewater River may have had further impact downstream at the confluence with the Whitewater River. Downstream of the confluence, station 89-01 had lower median concentrations of alkalinity, hardness, and dissolved solids compared with the median observation at station 88-06 above the confluence. Sulfate had a slight decrease in median concentration after the confluence. Conversely, chloride had a slight increase after the confluence.

From up to down stream along the Whitewater River, slight yet steady decreases in the water chemistry parameters of alkalinity, hardness, sulfate, and dissolved solids were observed. This was probably due to dilution and the absence of influence from small municipalities and agricultural runoff. Along the Whitewater River, chloride had slightly elevated observations at 88-02 and 88-03. This chemistry parameter had a very consistent range of observations along the river and did not appear to have the slight yet steady decrease observed with the other parameters.

Along the East Fork Whitewater River, stations 86-03 and 86-04 had the largest variation of dissolved solids, chloride, and sulfate. The quartile ranges for these three chemical parameters at these two stations were the largest quartile ranges observed in the basin. Since the station in Richmond, 86-01, did not have as large a range of observations and the median statistic was lower, the elevated dissolved solids, chloride, and sulfate, were probably the result of agricultural influences.

Surface Water Quality Violations

The surface water quality data were examined to decide if water quality standards were violated for dissolved solids, sulfate, and chloride. The surface water standards are 750 mg/L for dissolved solids, 250 mg/L for sulfate, 860 mg/L for chloride's acute aquatic criterion, and 230 mg/L for chloride's chronic aquatic criterion. Examination of the data revealed no surface water violations at any of the stations during the study.

Conclusions

General chemistry data for the 1997 Whitewater River Basin study were analyzed in three distinct manners. First, the data for all of the stations were compiled and analyzed using a statistical program. These statistics showed the shape, central tendency, and expected ranges for the water chemistry parameters.

Data for each sampling station were graphed on a box-whisker plot to learn if and where station's changes occurred along the East Fork Whitewater River and Whitewater River. Brookville Reservoir had a notable impact on the water chemistry. Water from the reservoir diluted the concentration for all of the general chemistry parameters. This was noted when stations 86-04 and 86-05 were compared. The confluence of the East Fork Whitewater River with the Whitewater River contributed to the dilution of all of the general chemistry parameters except chloride. Excepting chloride, the water chemistry along the Whitewater River slowly but steadily decreased in concentration.

The final analysis was to search the data for surface water quality violations. Analysis of the data shows no violations for dissolved solids, sulfate, and chloride.

VII *Escherichia coli*

by

Veronica A Erwin

Introduction

Stream water often carries pathogenic organisms that can limit the use of the water and cause illness to persons contacting or ingesting the water (Terrio 1995). Determining the concentration of these bacterial pathogens shows the degree of fecal contamination from human or animal sources. Several types of fecal-indicator organisms can be used. The *Escherichia coli* (*E. coli*) organism is an indicator of fecal contamination because it commonly inhabits the intestinal tracts of humans and warm-blooded animals, and it is generally present in large numbers. The U.S. Environmental Protection Agency strongly recommends that *E. coli* be used as an indicator of bacteria for fresh waters because it has been found to correlate with fecal coliform densities (Dufour 1986). *E. coli* was selected as the indicator of fecal contamination in waters of Indiana.

Generally two means of surface water contamination from bacteria are considered. The first is from *point sources*, such as discharges of treated and untreated sewage. Sources of bacteria in streams of a watershed vary as a function of weather conditions (Weiskel et. al. 1996). During heavy rain events, flooding, or power outages, sewage treatment facilities may need to discharge wastewater laden with bacteria directly into the surrounding surface waters. This happens either because of sanitary sewer overflows or because of combined storm water overflows (NCSU Water Quality Group).

The second source of bacterial contamination is called a *nonpoint source*. Nonpoint source contamination occurs over a more widespread area than point-source, and is more difficult to define. In rural areas, runoff from agricultural practices can wash animal bacteria from water saturated land surfaces into surrounding streams. Septic drainage from wastewater disposal systems and storm water runoff from construction sites are examples of non-point sources that can occur in both rural and urban areas.

To examine the combined potential impact of both point and nonpoint sources, this study sampled water for *E. coli* in the Whitewater River Basin to show how much contamination from warm-blooded animals was present.

Methods

Surface water in the Whitewater River Basin was sampled at nineteen locations including major and minor tributaries. Six separate surveys were conducted in this basin during 1997, resulting in a total of 114 sampling events. Water samples were collected and analyzed for parameters indicative of water quality. *E. coli* was not sampled during every survey. During this study, samples for *E. coli* were collected within the recreational season between the months of April and October, inclusive. When *E. coli* was sampled, a one-part grab sample was collected and analyzed according to Standard Methods (APHA 1995).

Indiana Administrative Code 327 IAC 2-1-6 stipulates that samples are to be analyzed within six hours of collection. To include more data in this analysis, samples analyzed within twenty-four hours were also used to assess the basin.

Results and Discussion

Sampling of the basin was conducted in three intervals during the recreational season: late Spring (from late May to early June), Summer (mid July), and late Summer/early Fall (late September to Early October). Although some stations had results from only one sampling event to represent it for the year, most stations (70%) had data from three sampling events. This data is given in Appendix D. This information is further presented as a set of box plots in Figures VII·1 and VII·2. For these figures, stations were grouped according to major tributaries that run through the basin and arranged from upstream to downstream whenever possible. The box plots for each station are based on three data points and are presented as a single data point.

Indiana Administrative Code 327 IAC 2-1-6 specifies that a waterbody with an *E. coli* count at or above 235 colony forming units (cfu) per 100 milliliter (mL) in any one sample in a thirty-day period is unsuitable for full body contact (e.g., swimming). For this report, median rather than mean values are computed, presented and compared with the recommended standard of 235 cfu/100mL. This value is used in this report to evaluate surface waters throughout the basin.

Figure VII·1 represents *E. coli* results for the main stem Whitewater River and associated tributaries. Stations in this portion of the basin had medians below or close to the standard except station 89-02, Blue Creek. This station had an *E. coli* count of 800 cfu/100mL in late spring. Spring rains causing high run off may have been the factor for this high count.

Figure VII·1

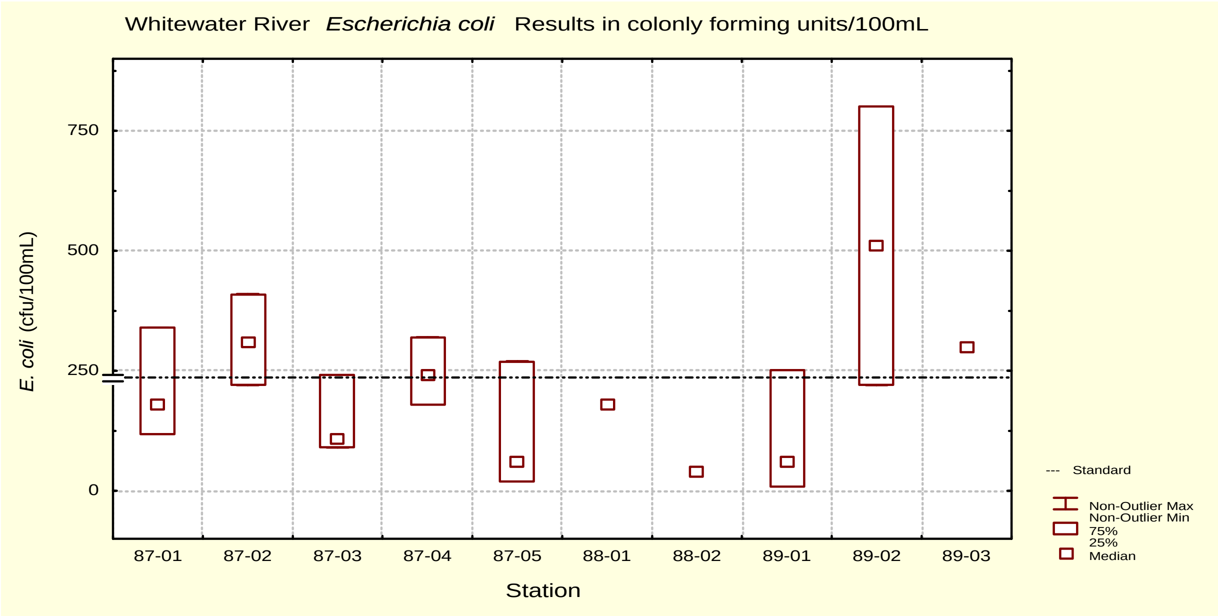
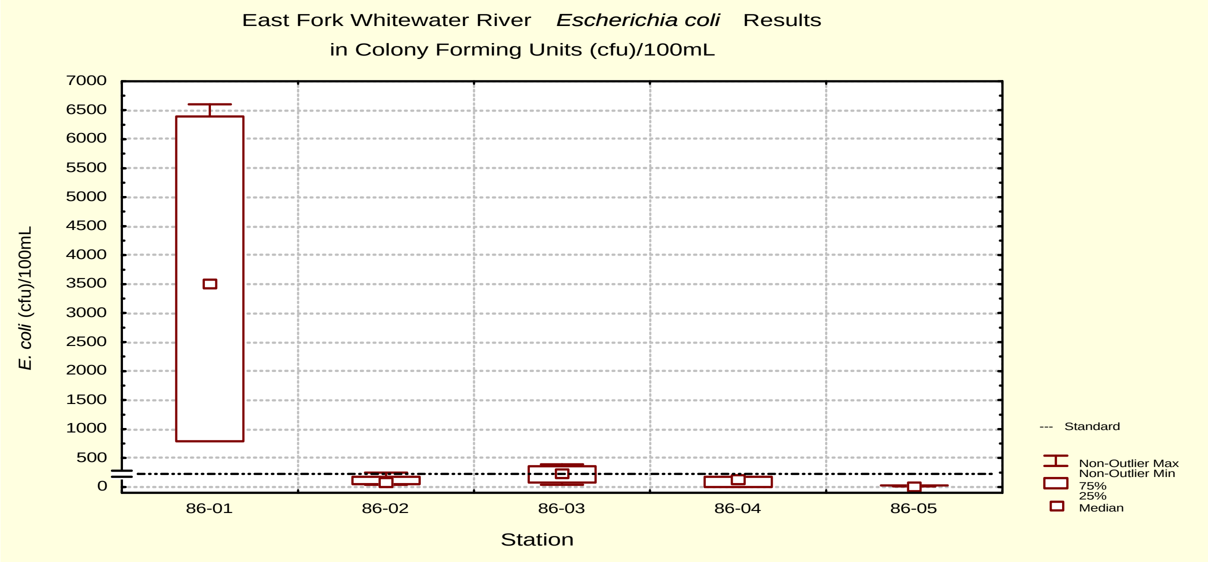


Figure VII·2 represents *E. coli* counts for the East Fork Whitewater River as it passes through the city of Richmond. Station 86-01, on the East Fork of the Whitewater River, had consistent counts over the standard for the sampling season with a late Summer count of 6,600 cfu/100mL.

Figure VII·2



Summary and Conclusions

Further analyses correlating *E. coli* counts with dissolved oxygen concentrations, suspended solid concentrations, turbidity and flow are recommended to pinpoint problems in this basin. Also recommended is follow-up testing according to the Surface Water Quality Monitoring Strategy (IDEM 1996) for the stations that are above Water Quality Criteria. The most serious limitation of this study is the conservative amount of data on which it is based. This should be taken into consideration when evaluating data for such studies as total maximum daily loads (TMDL) and others that depend on the results from bacteriological testing. Resources need to be allocated in this area to assess the validity of the current restrictions for this parameter.

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Appendix A

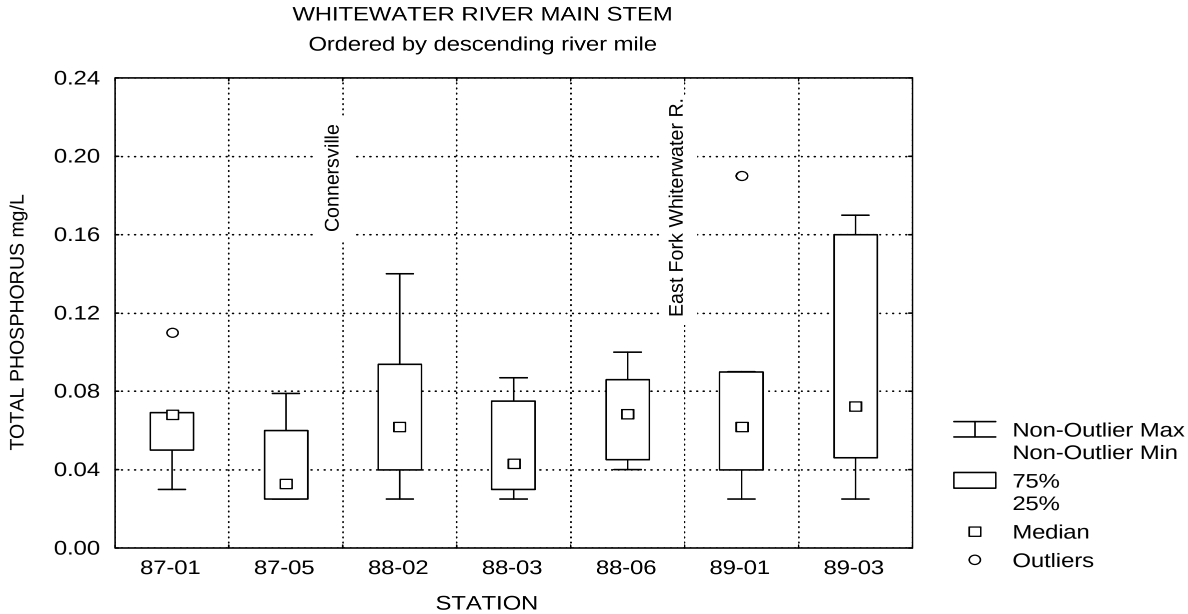
Whitewater River Basin
1997 Synoptic Sampling Sites

Site	Stream	Location	County	Quad Map	Sub Unit	Influences, Land Usage, or Special Concerns
Segment 86 - East Fork, Whitewater River			**Major** Hydrologic Unit-- 05080003			
86-1	E. F. Whitewater River	Hodgin Pkwy. Richmond	Wayne	F-22	050	Agriculture / Recreation / Urban
86-2	W. F., E. F. Whitewater River	Bridge Ave. Richmond	Wayne	F-22	050	Industrial / Urban
86-3	E. F. Whitewater River	Beelor Rd.	Wayne	F-22	050	Agriculture / Forest / NPDES
86-4	E. F. Whitewater River	Abington, Potter Shop Rd	Wayne	F-45	050	Agriculture / Forest / U.S.G.S.
86-5	E. F. Whitewater River	SR 101, Brookville	Franklin	G-21	050	Reservoir / U.S.G.S.
Segment 87 - Upper West Fork, Whitewater River			**Major** Hydrologic Unit-- 05080003			
87-1	Whitewater River	Meyers Rd.	Wayne	F-20	010	Industrial / Urban / U.S.G.S.
87-2	Martindale Creek	Germantown Rd.	Wayne	F-20	010	Agriculture / NPDES
87-3	Greens Fork	Jacksonburg Rd.	Wayne	F-21	010	Agriculture / NPDES / Forest
87-4	Nolands Fork	CR 440, Waterloo	Fayette	F-44	020	Agriculture / NPDES / Forest
87-5	Whitewater River	Roberts Park, Connersville	Fayette	F-44	020	Agriculture / Forest / Urban

Site	Stream	Location	County	Quad Map	Sub Unit	Influences, Land Usage, or Special Concerns
Segment 88 - Lower West Fork, Whitewater River			**Major Hydrologic Unit-- 05080003**			
88-1	Williams Creek	CR 225 S, south of Connersville	Fayette	F-66	020	Agriculture / Forest /
88-2	Whitewater River	CR 480S, Nulltown	Fayette	F-66	020	Agriculture / Forest / NPDES / U.S.G.S.
88-3	Whitewater River	Laurel Road	Franklin	G-20	040	Agriculture / Forest / Residential
88-4	Salt Creek	SR 229, Metamora	Franklin	G-20	030	Forest / NPDES
88-5	Pipe Creek	Pipe Creek Road	Franklin	G-21	040	Agriculture / Forest / Reference
88-6	Whitewater River	Sixth St., Brookville	Franklin	G-21	040	Agriculture / Urban
Segment 89 - Whitewater River			**Major Hydrologic Unit-- 05080003**			
89-1	Whitewater River	Blue Creek Road	Franklin	G-21	060	Urban / NPDES / U.S.G.S.
89-2	Blue Creek	Highland Center Road	Franklin	G-21	060	Forest / Reference
89-3	Whitewater River	US 52, State Line	Dearborn	G-46	060	Forest / Agriculture

Appendix B

Figure B•1



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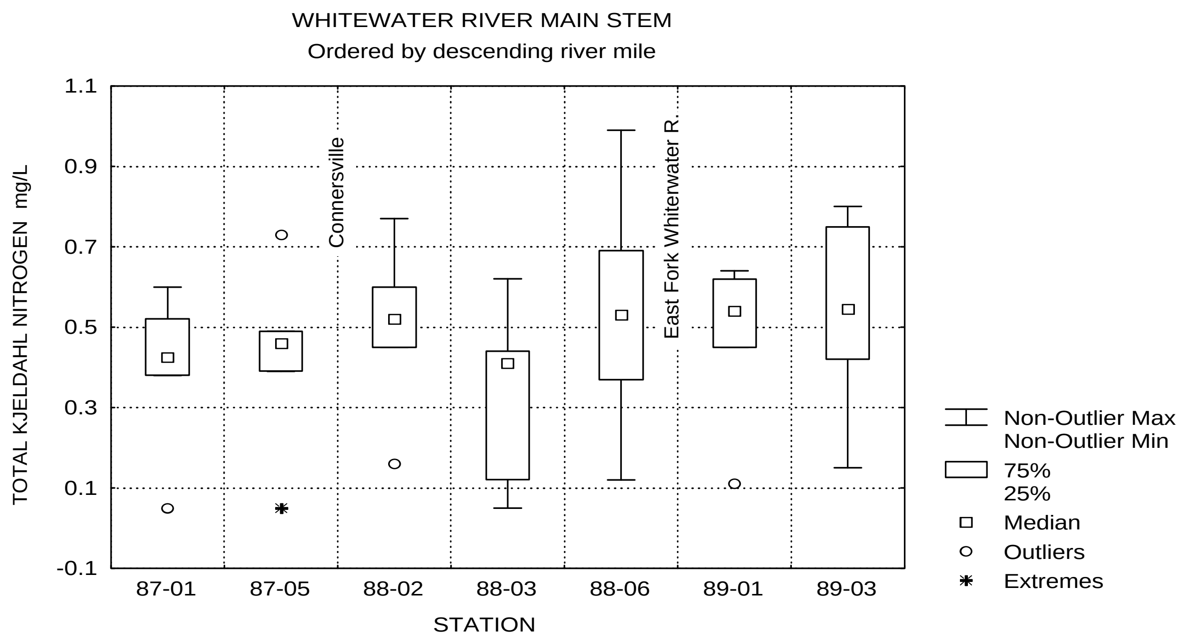

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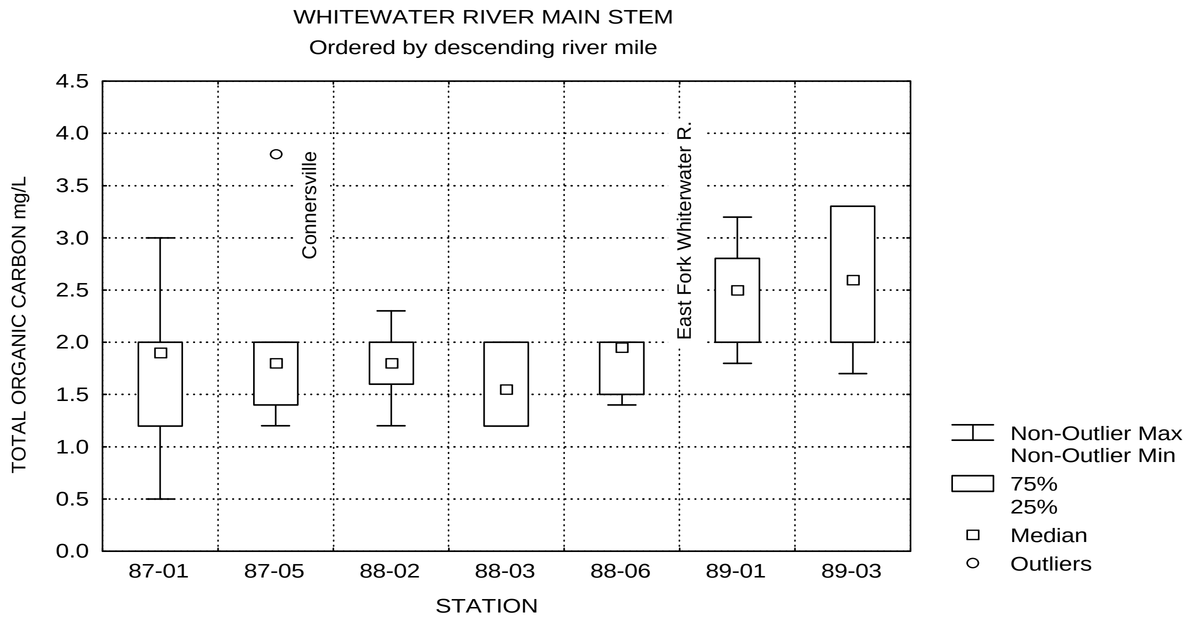
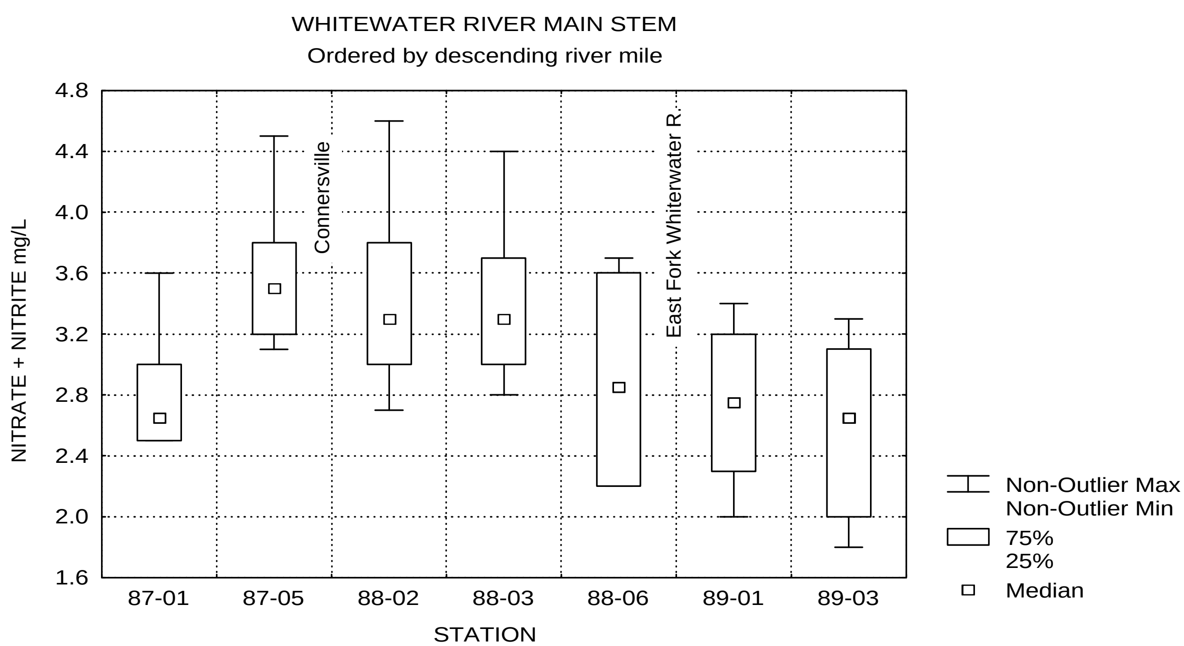


Figure B•4



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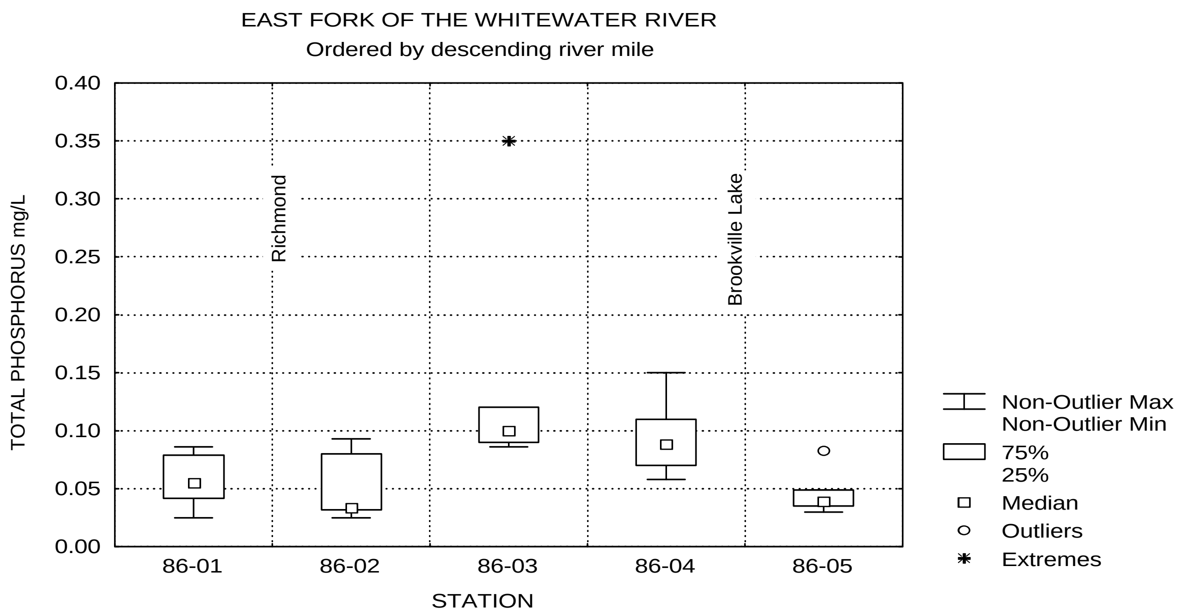
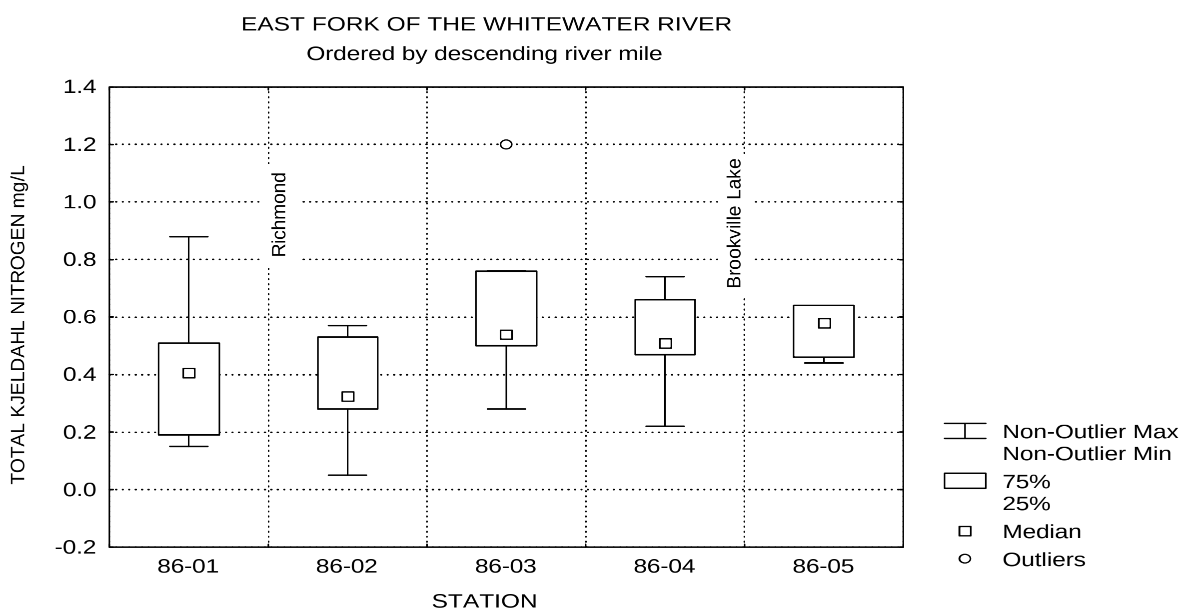


Figure B•6



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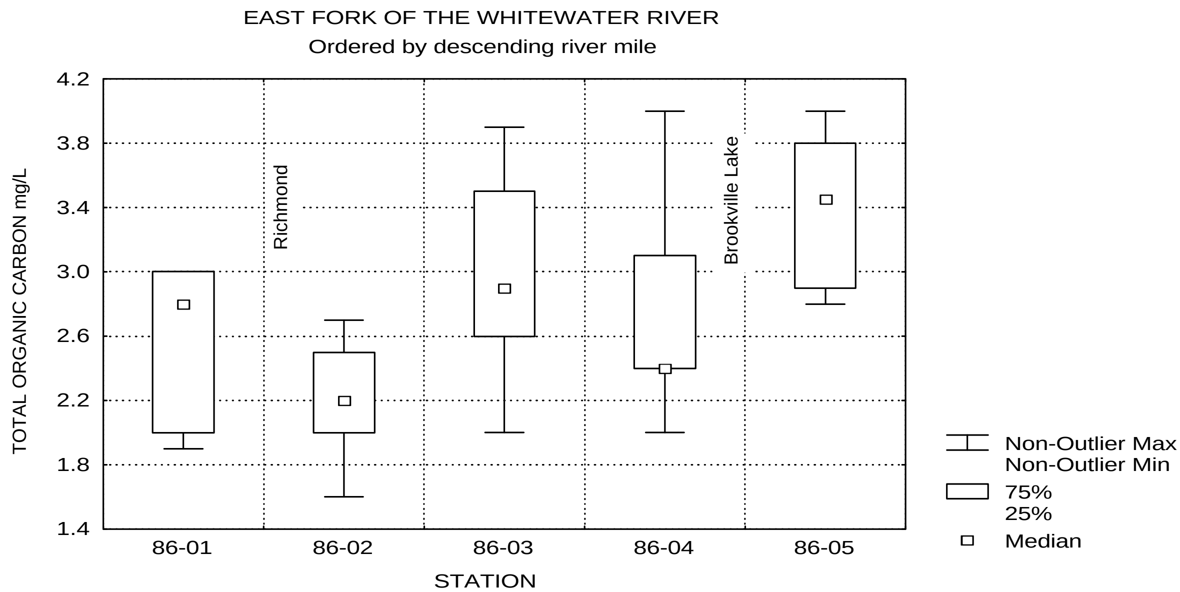

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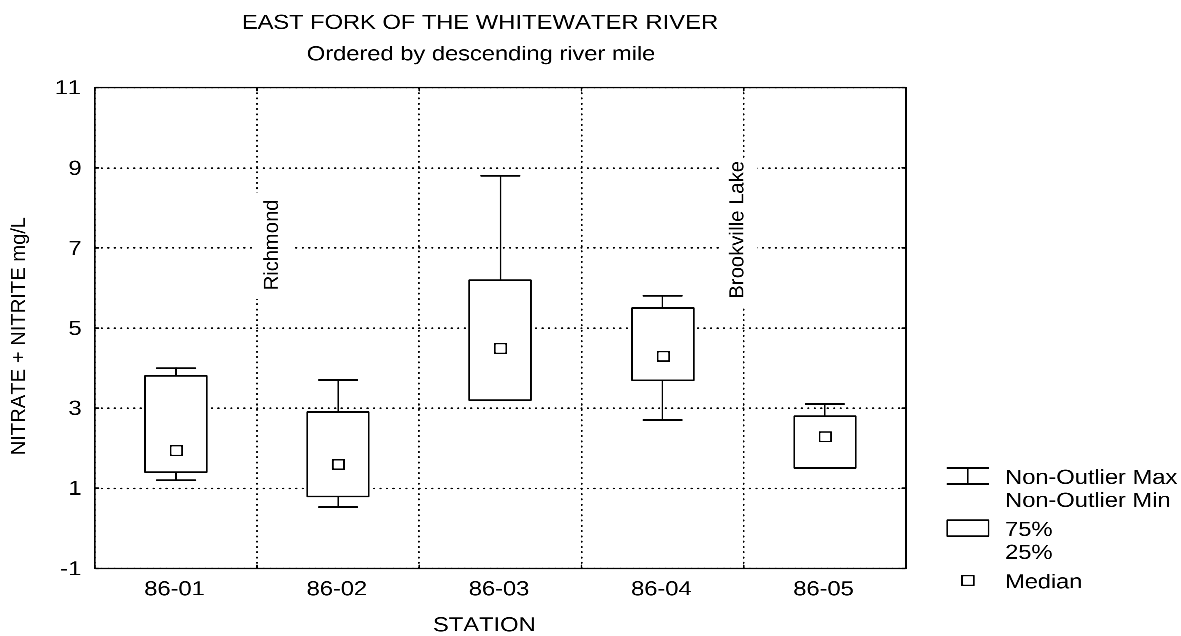

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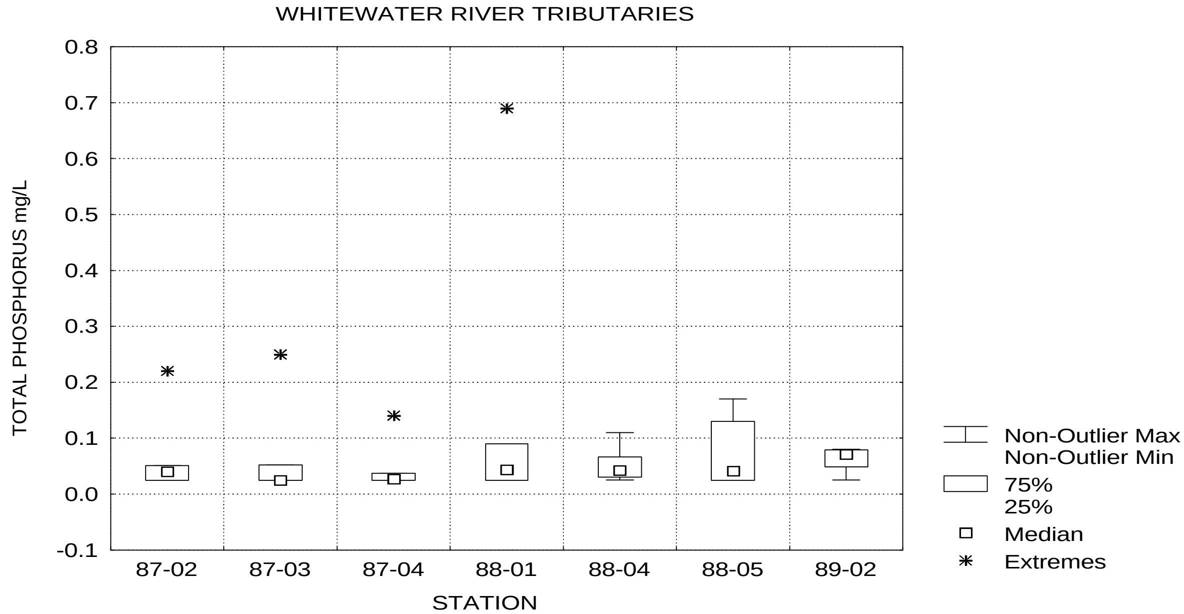

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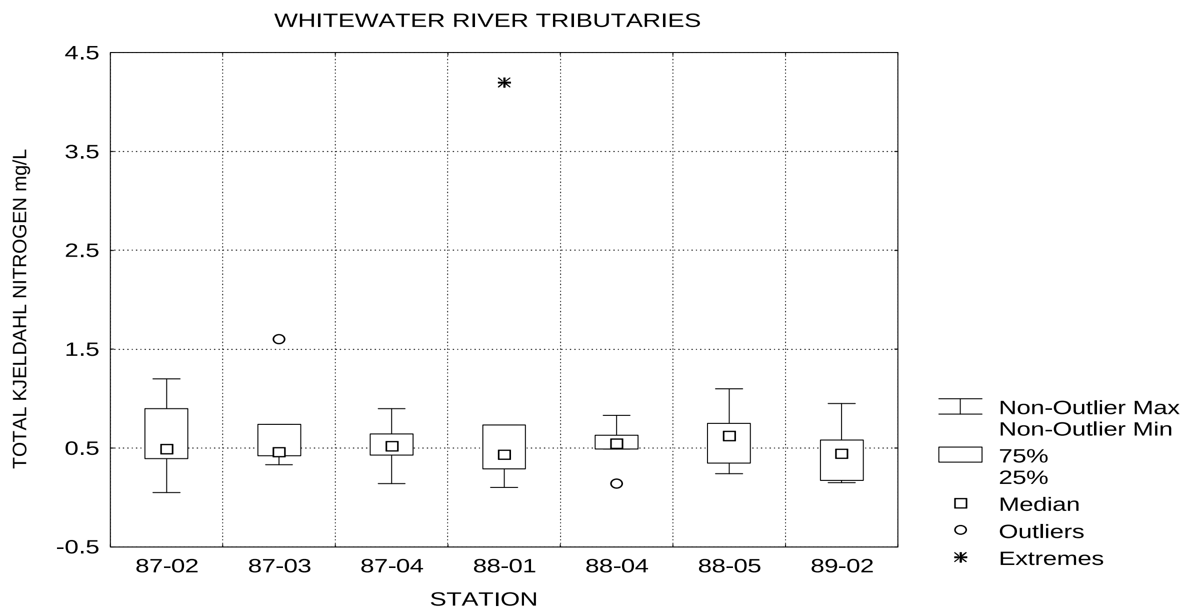
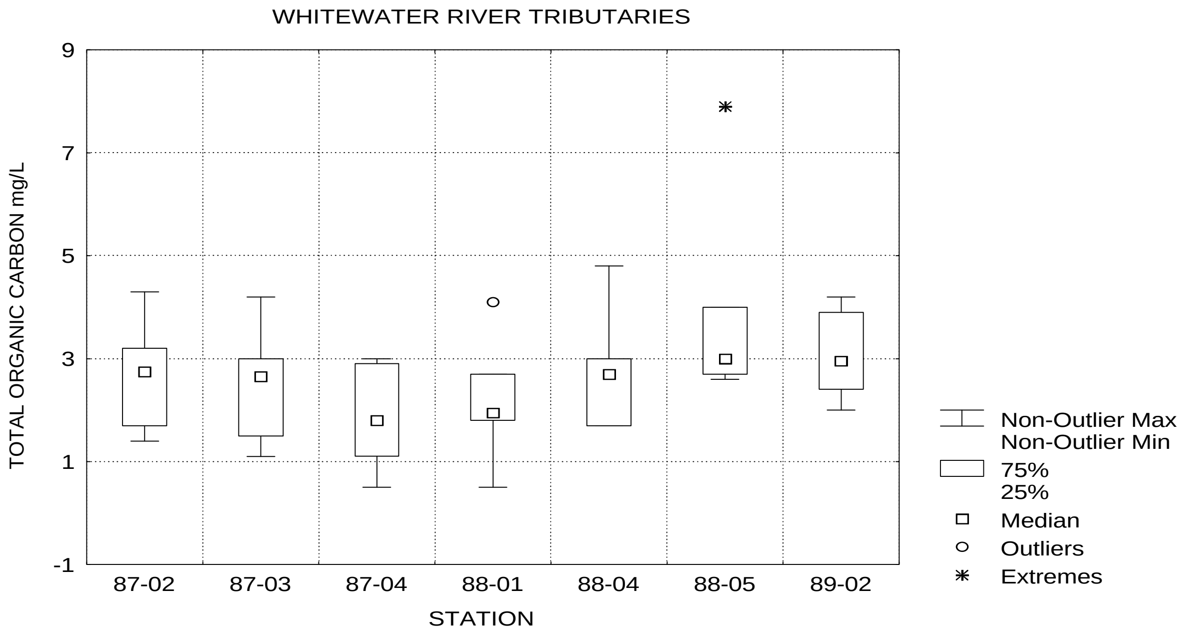


Figure B•11



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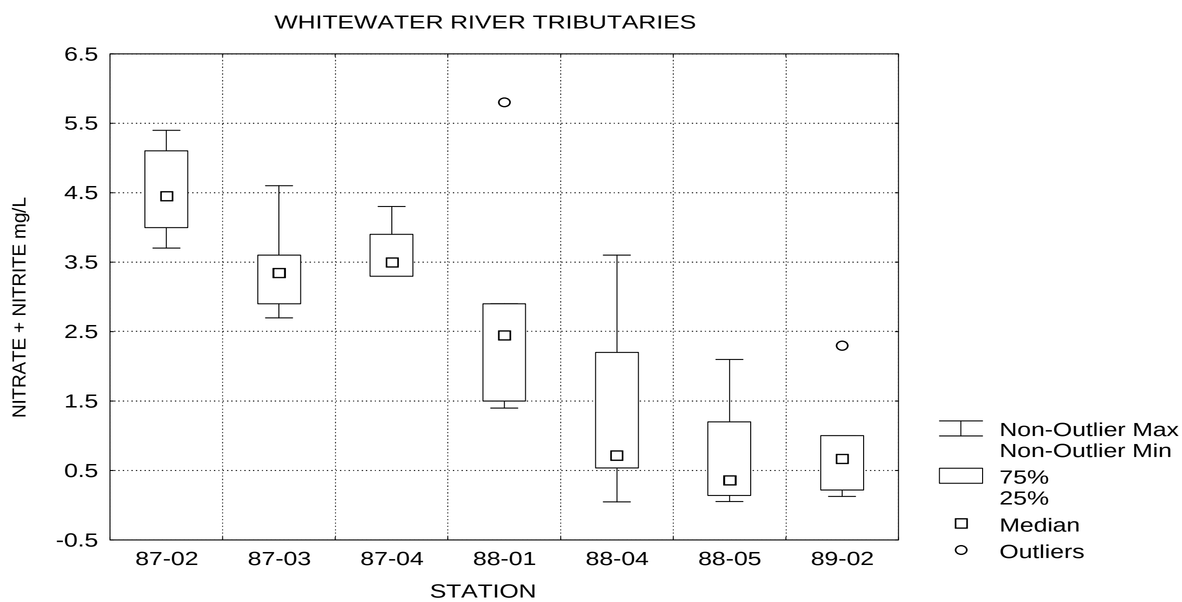

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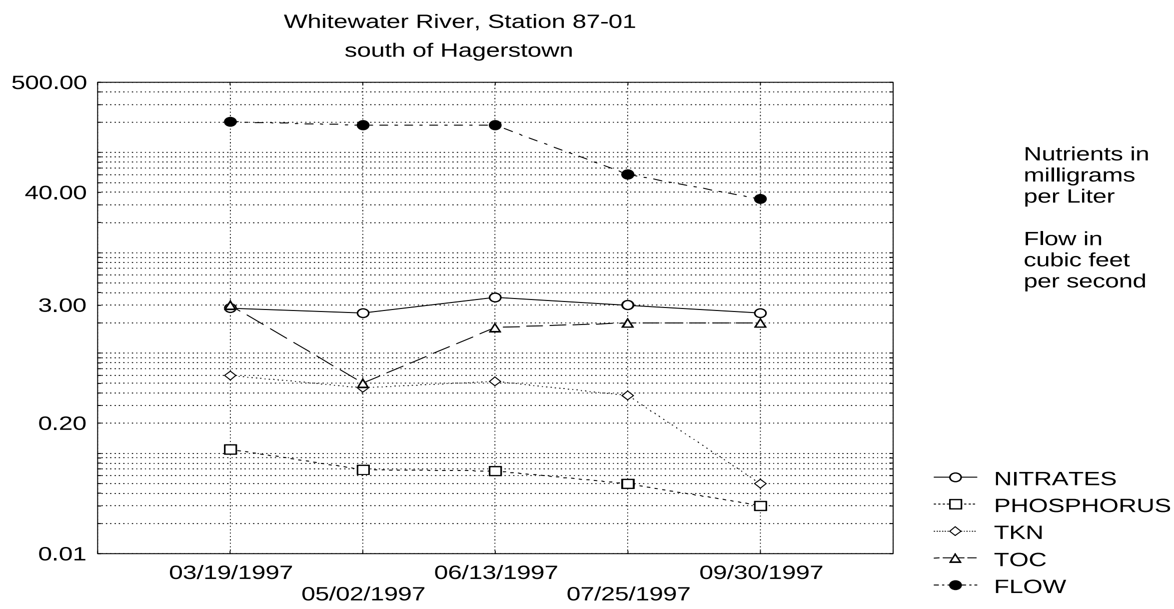

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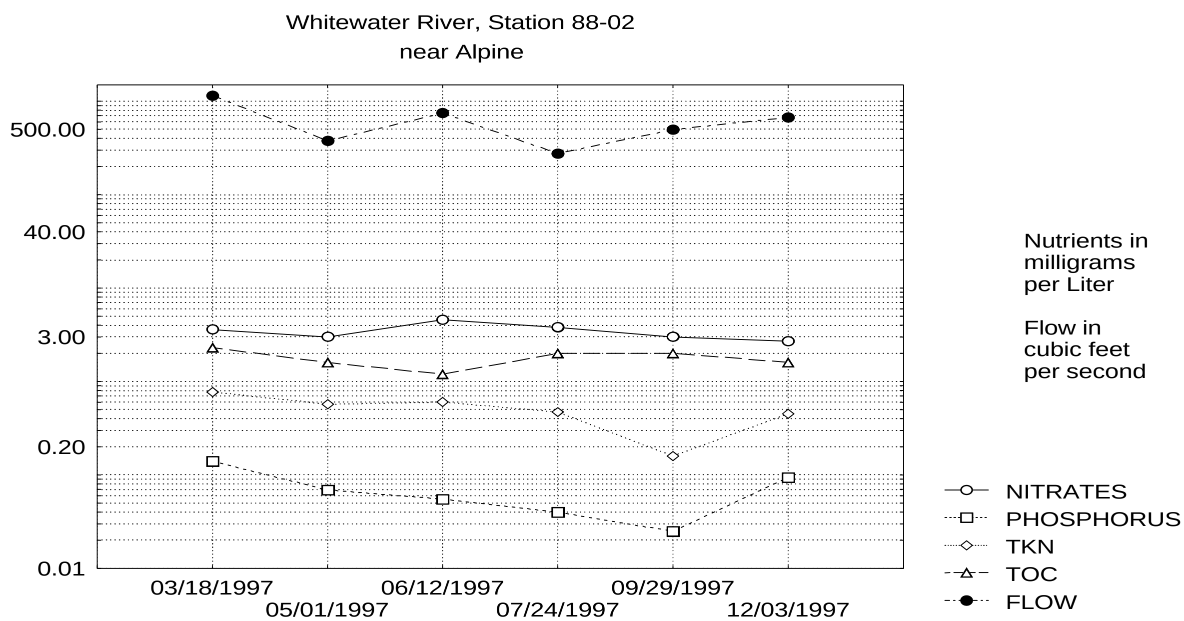


Figure B•15

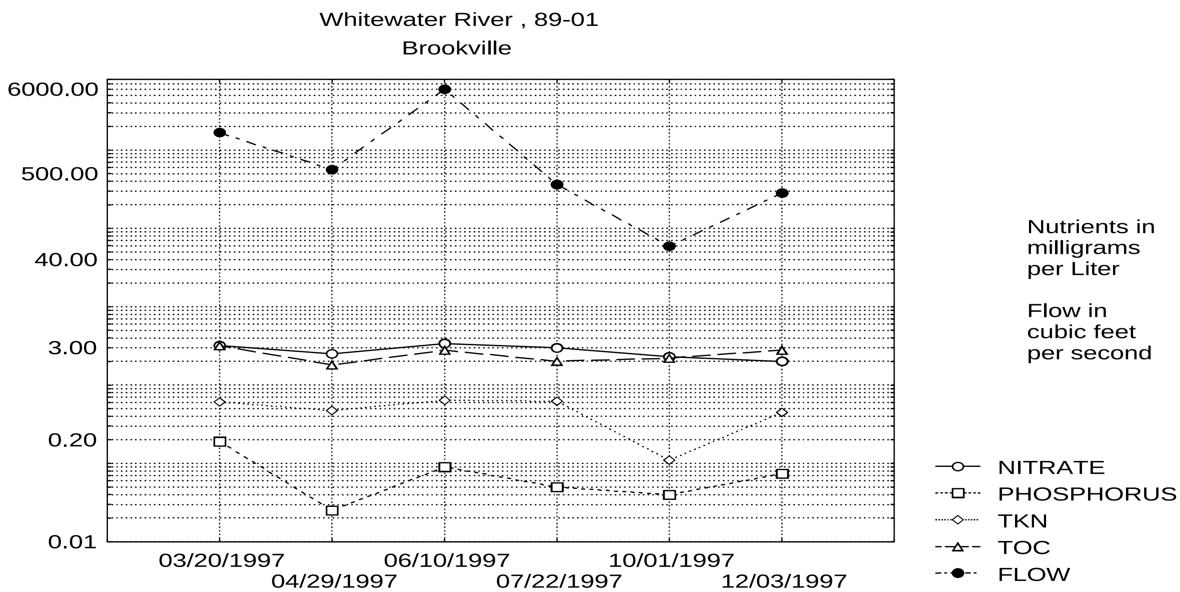


Figure B•16

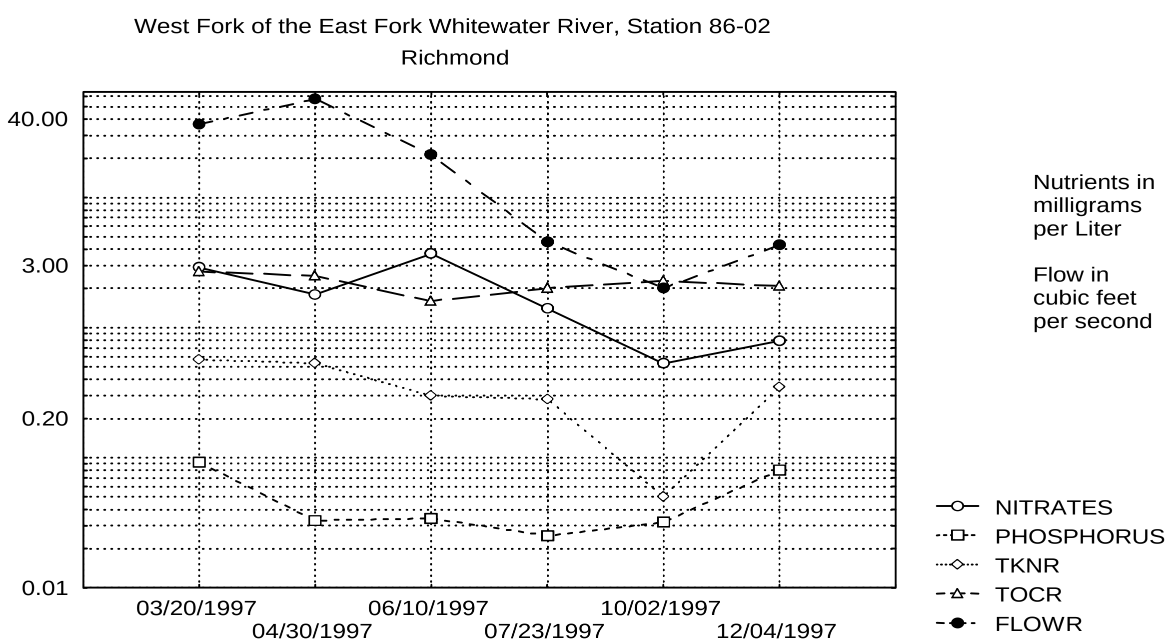


Figure B•17

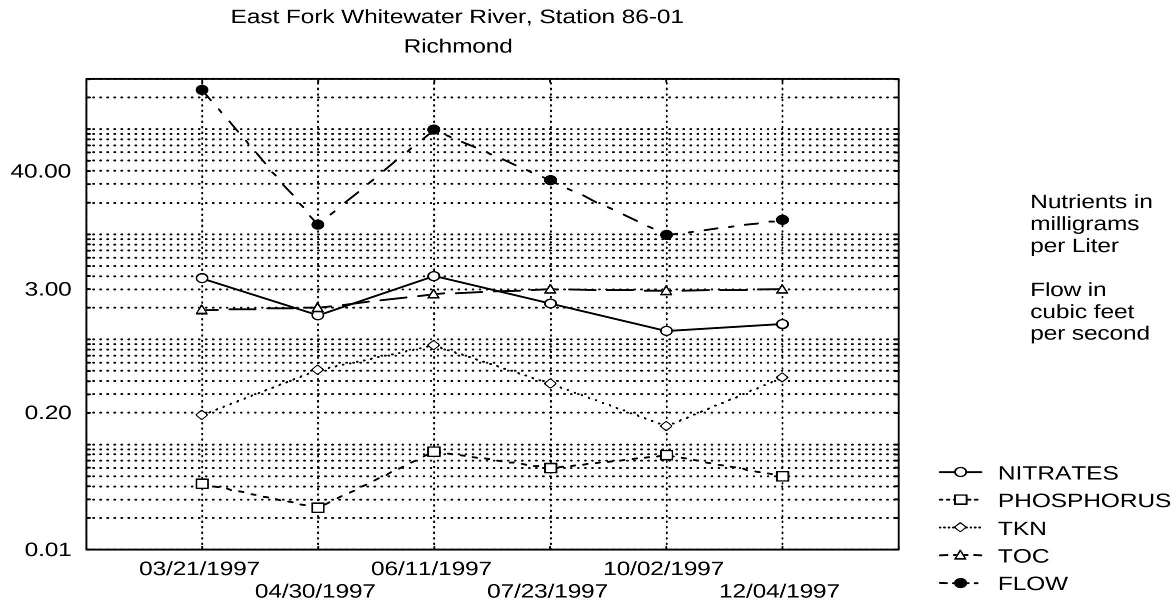


Figure B•18

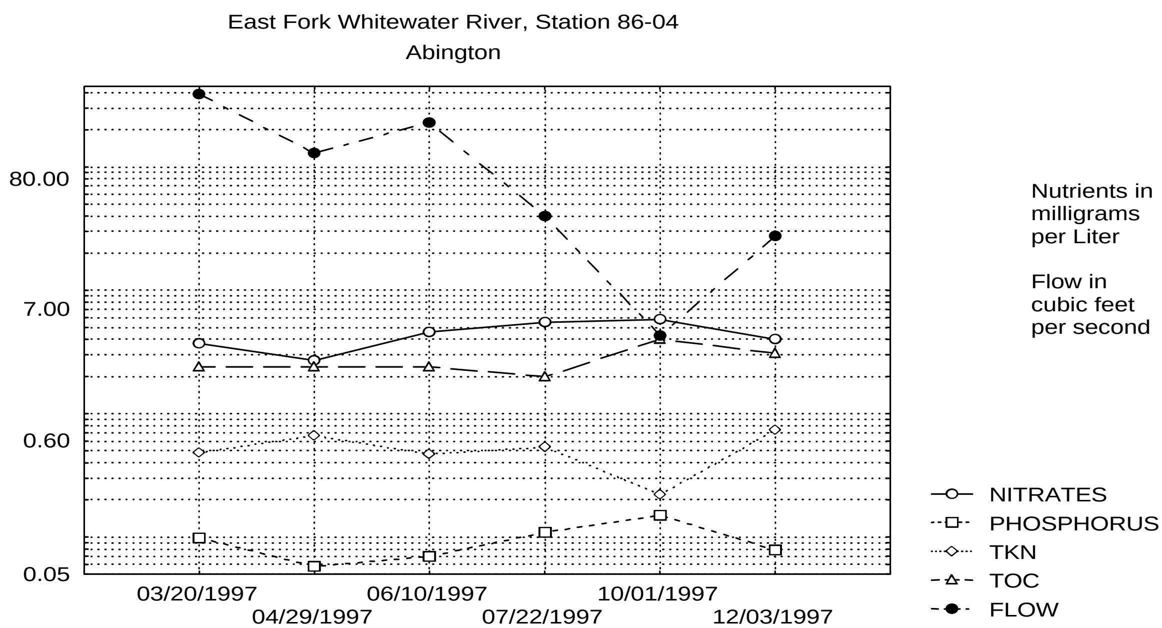


Figure B•19

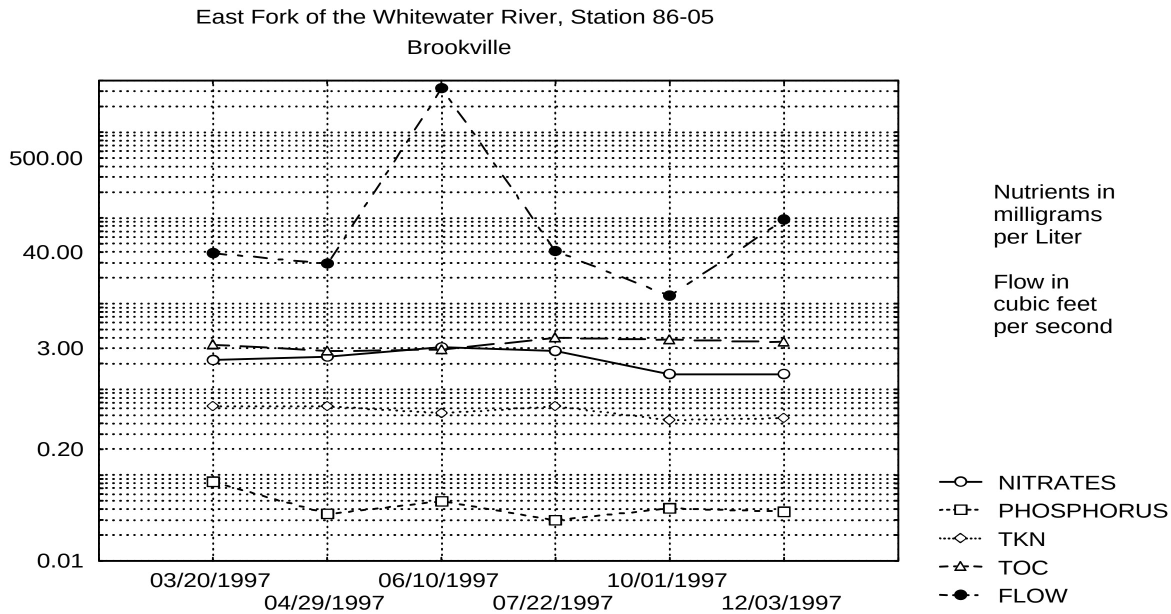


Figure B•20

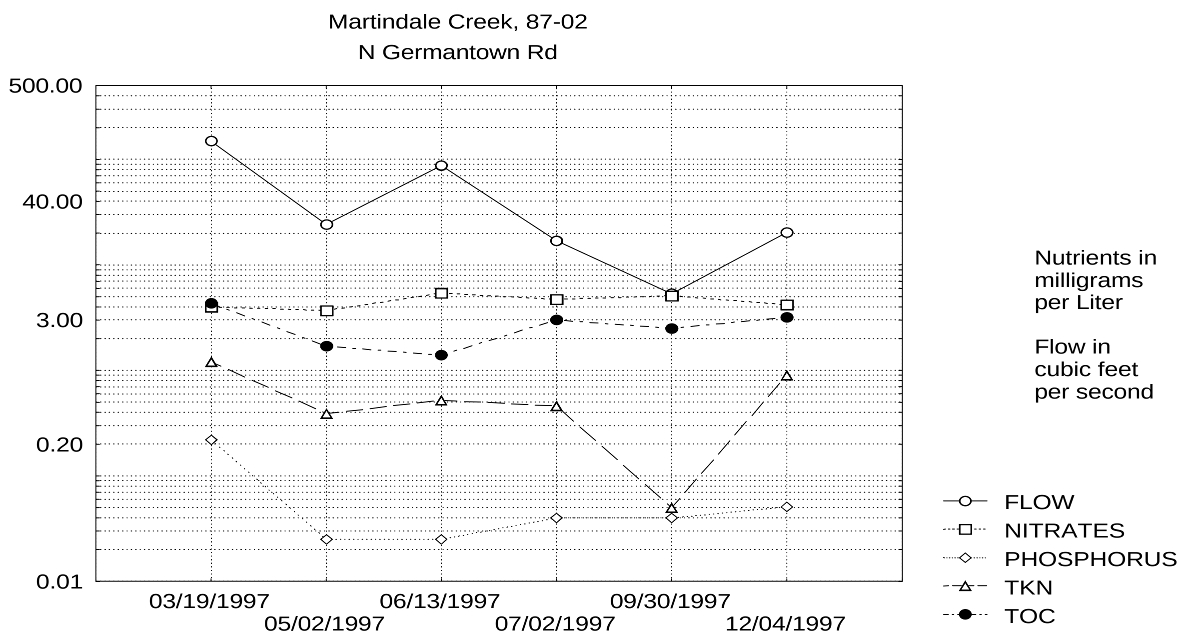


Figure B•21

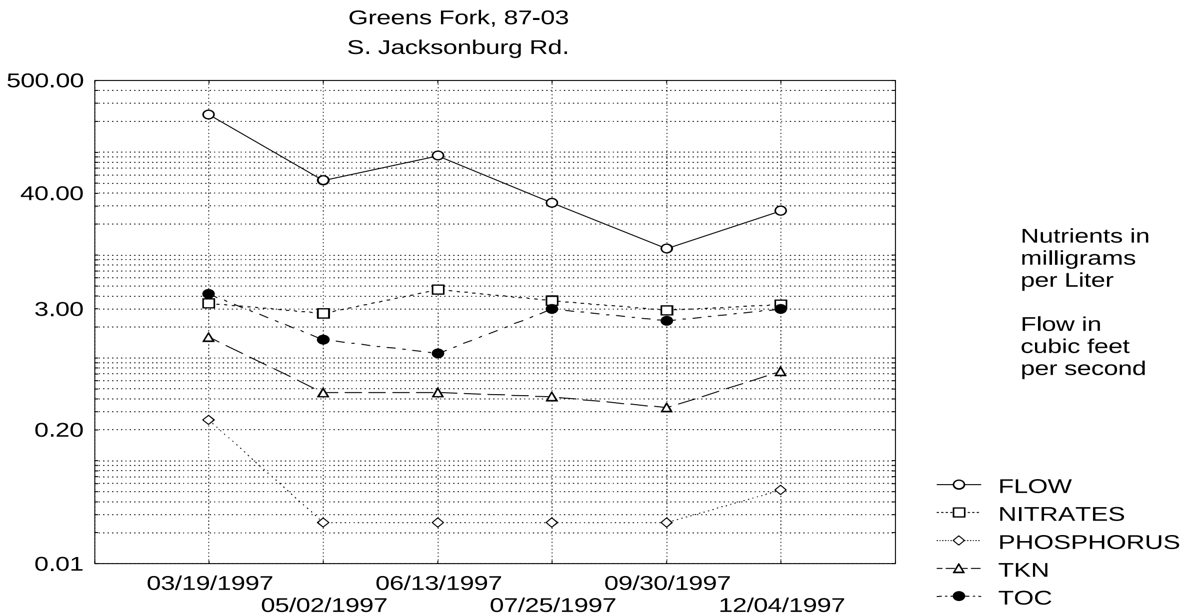


Figure B•22

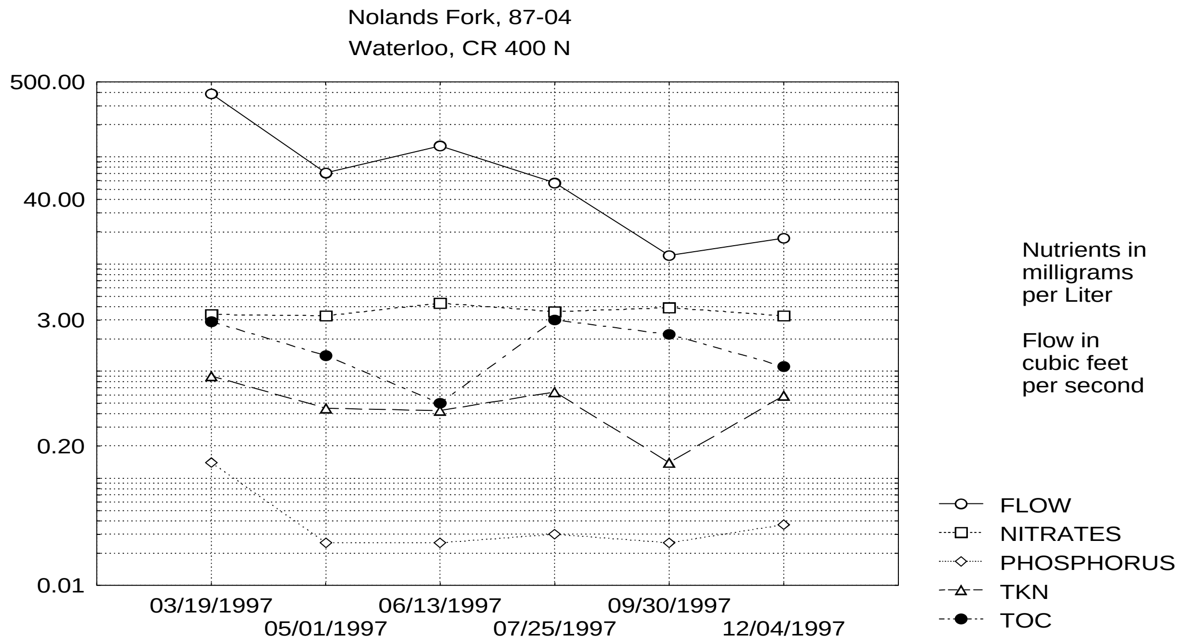


Figure B•23

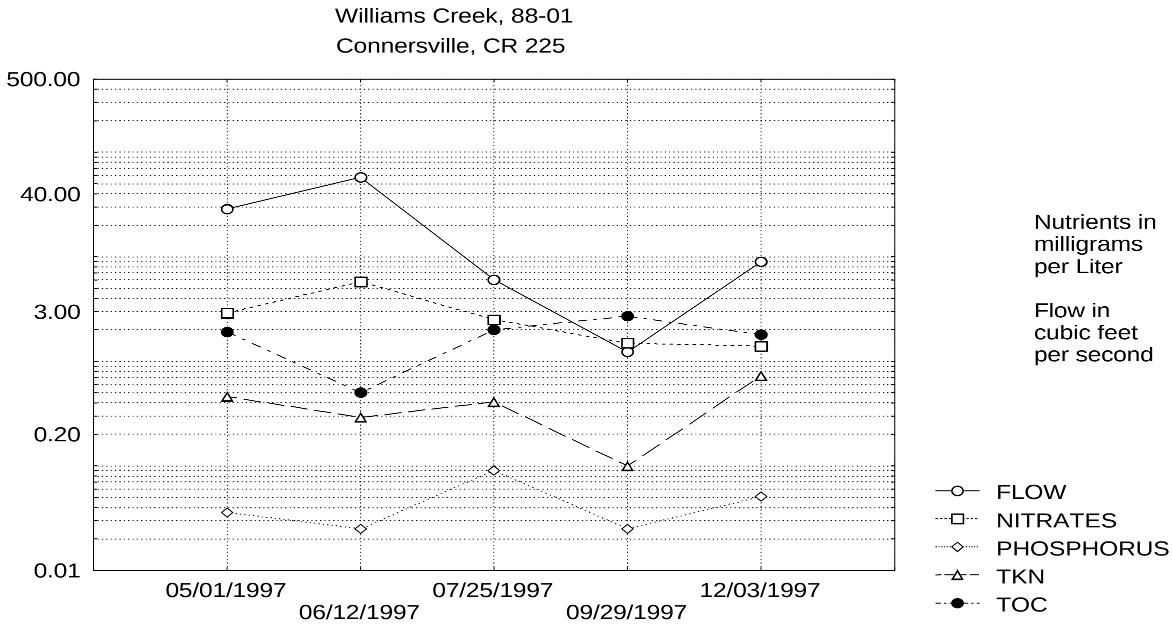
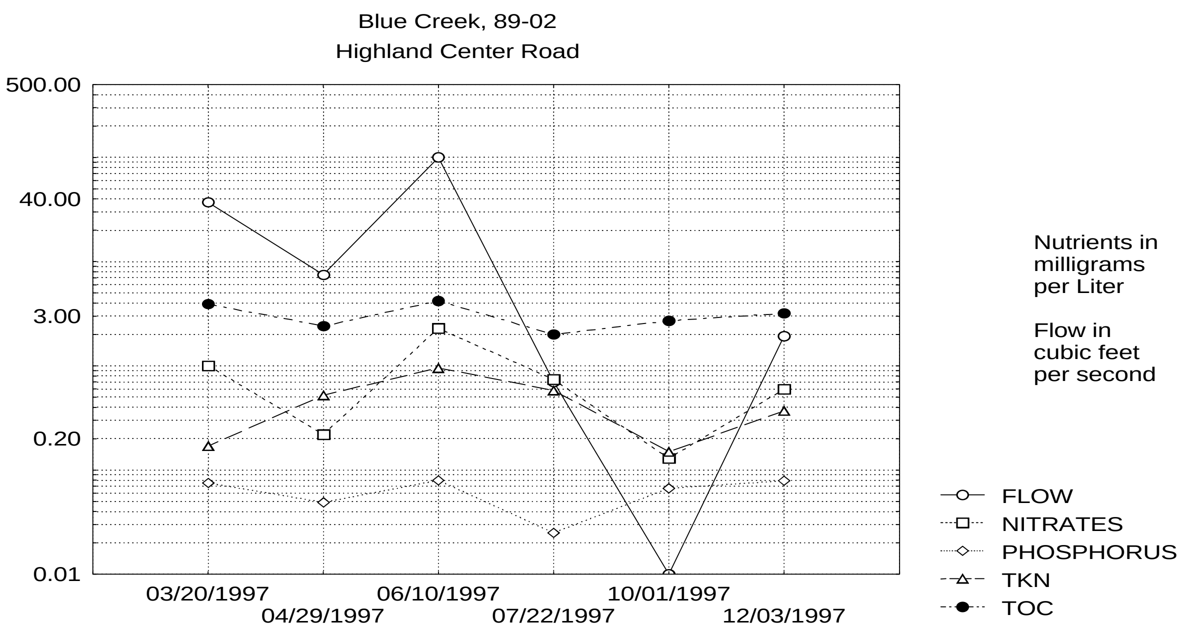


Figure B•24

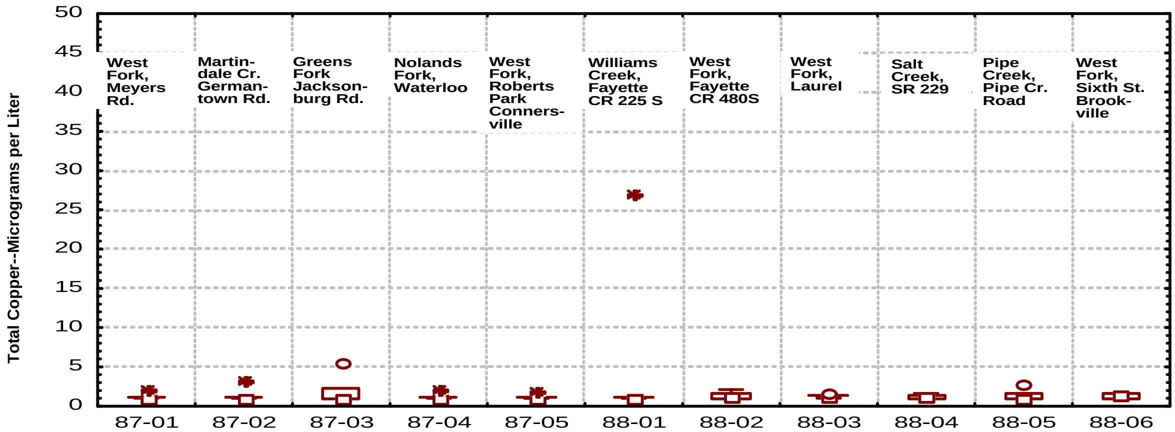


Appendix C

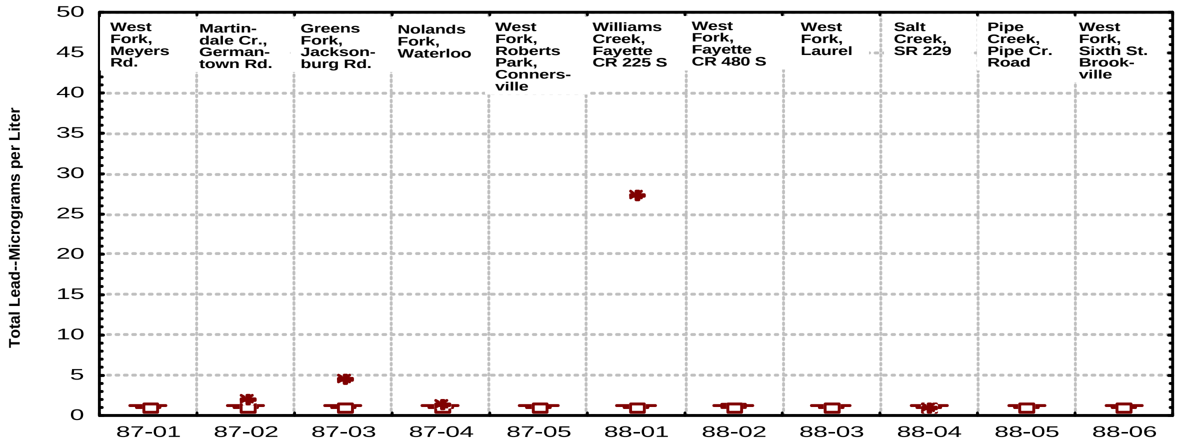
Important:
It should be noted that the default values for the box plots and the histograms are the method detection limits for each of the parameters. Values below detection limits are recorded at the detection limit.

West Fork Whitewater River & Tributaries--1997 (Upstream to Downstream)

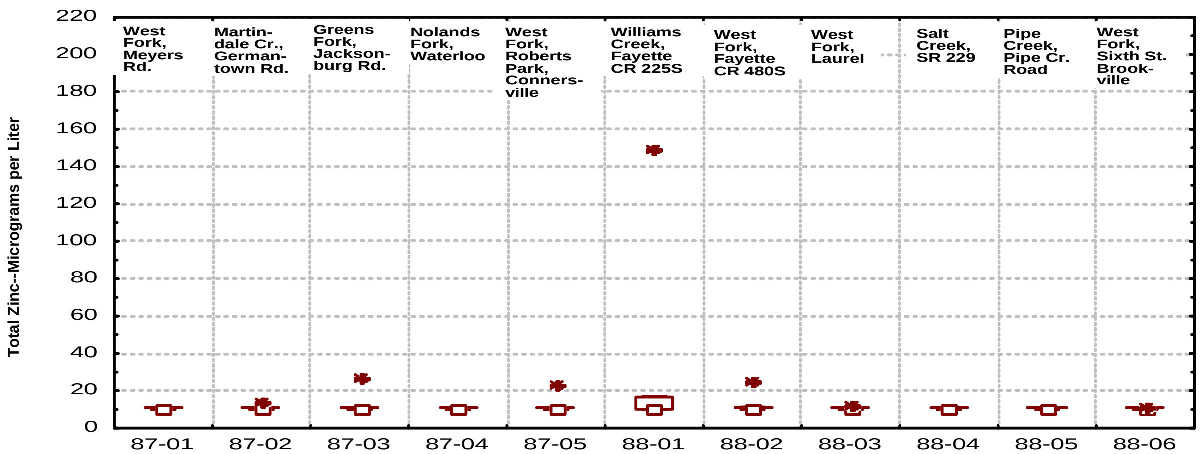
Total Copper



Total Lead



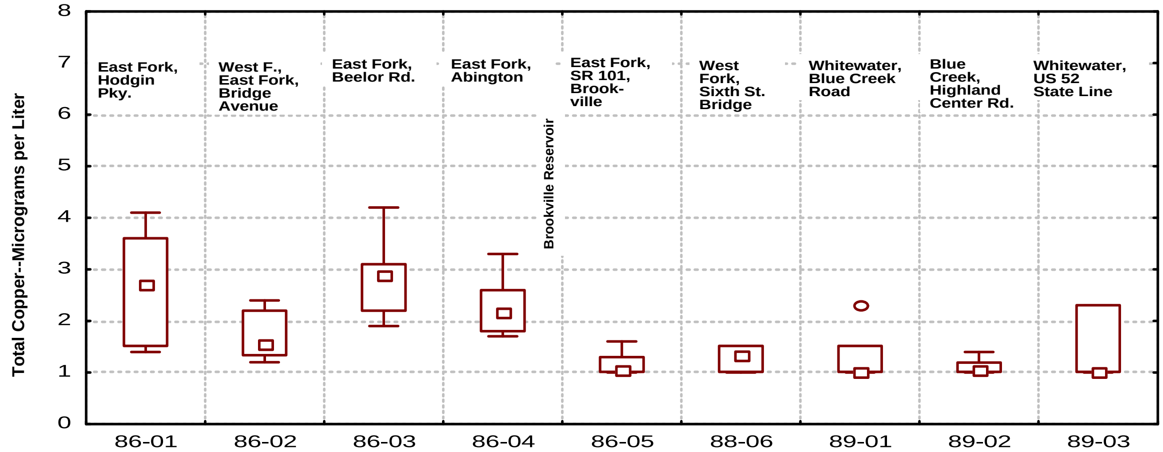
Total Zinc



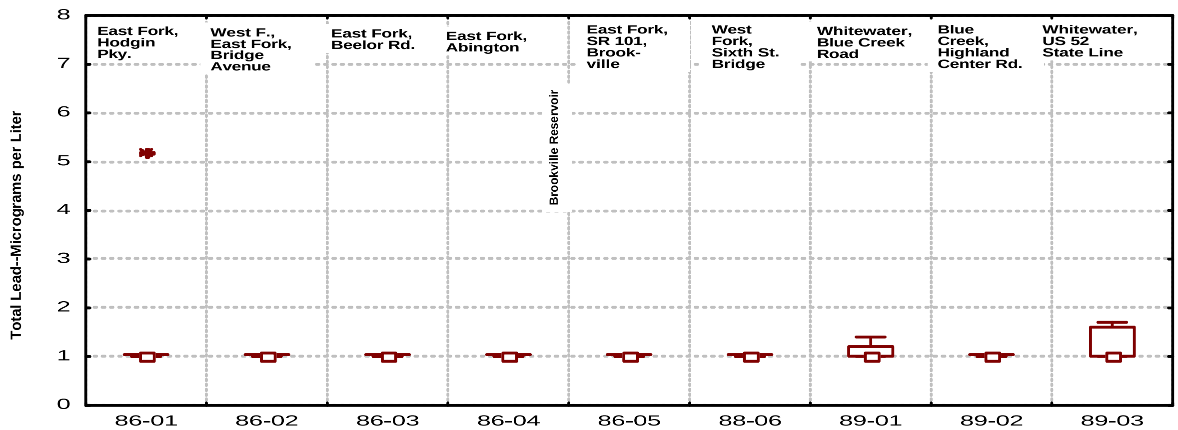
Detection Limits: Micrograms per Liter Copper 1.0 Lead 1.0 Zinc 10.0

Whitewater River & East Fork--1997 (Upstream to Downstream)

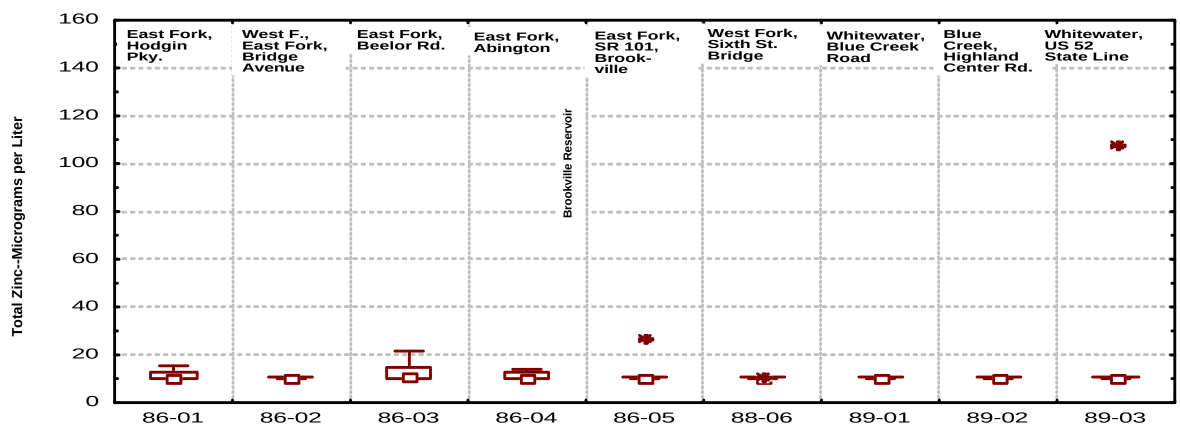
Total Copper



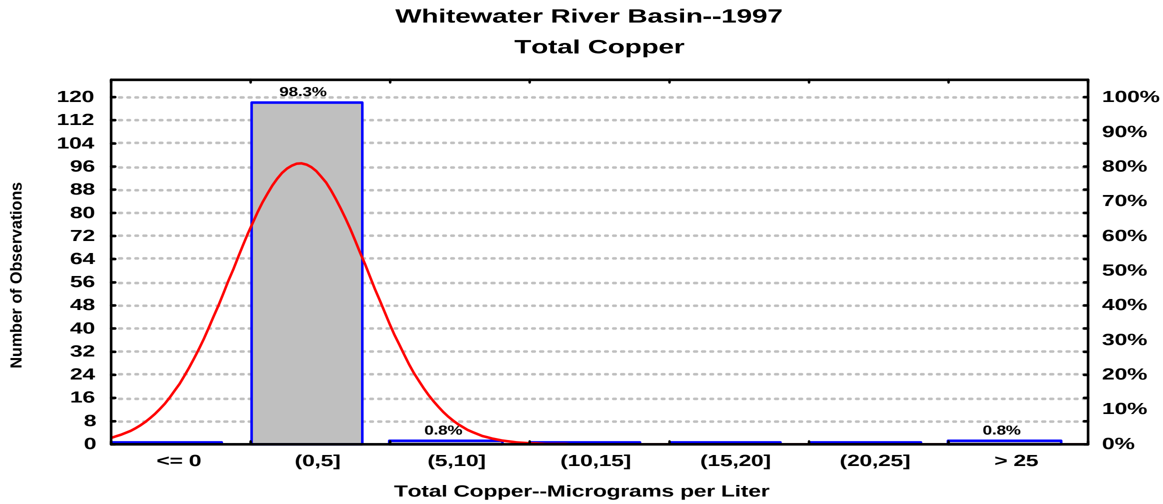
Total Lead

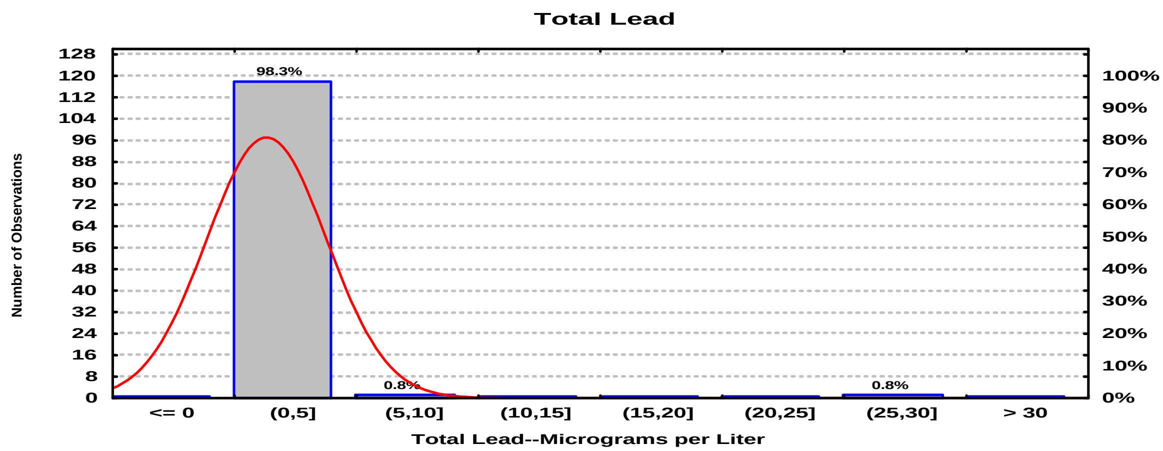


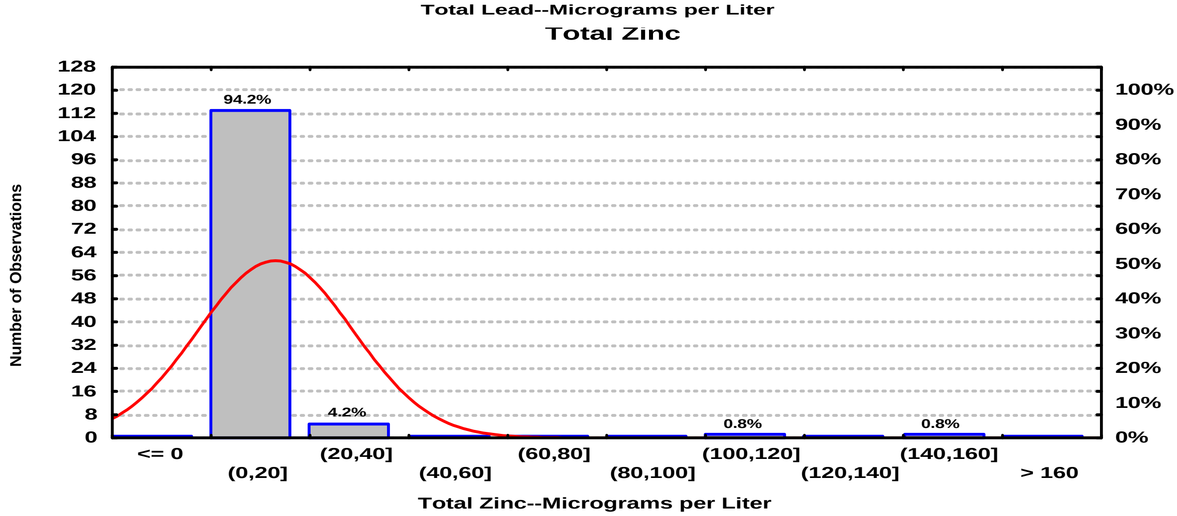
Total Zinc



Detection Limits: Micrograms per liter Copper 1.0 Lead 1.0 Zinc 10.0

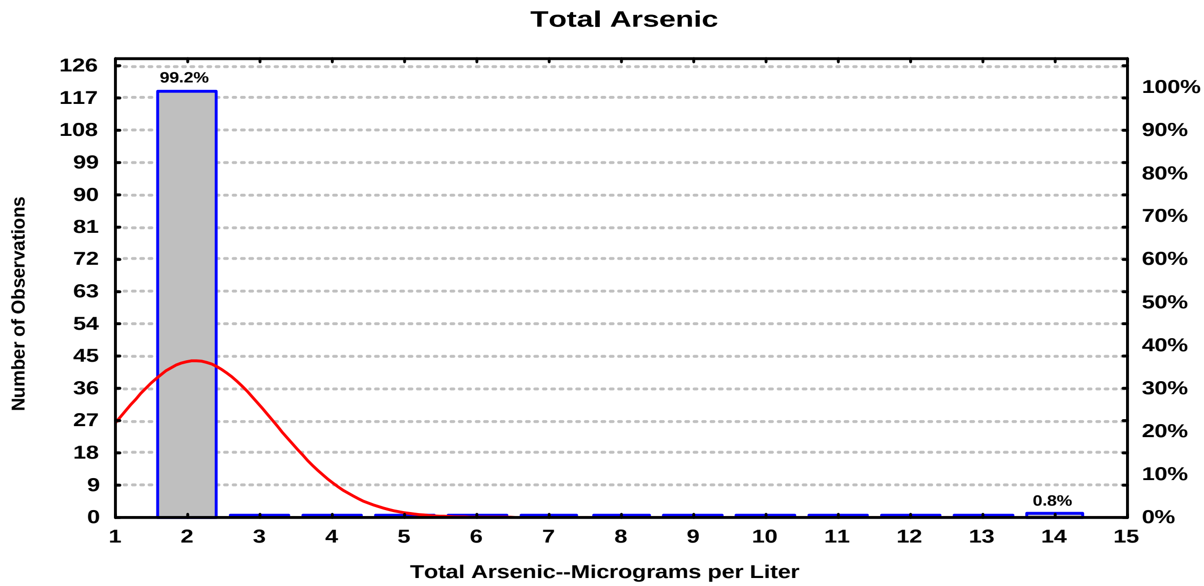


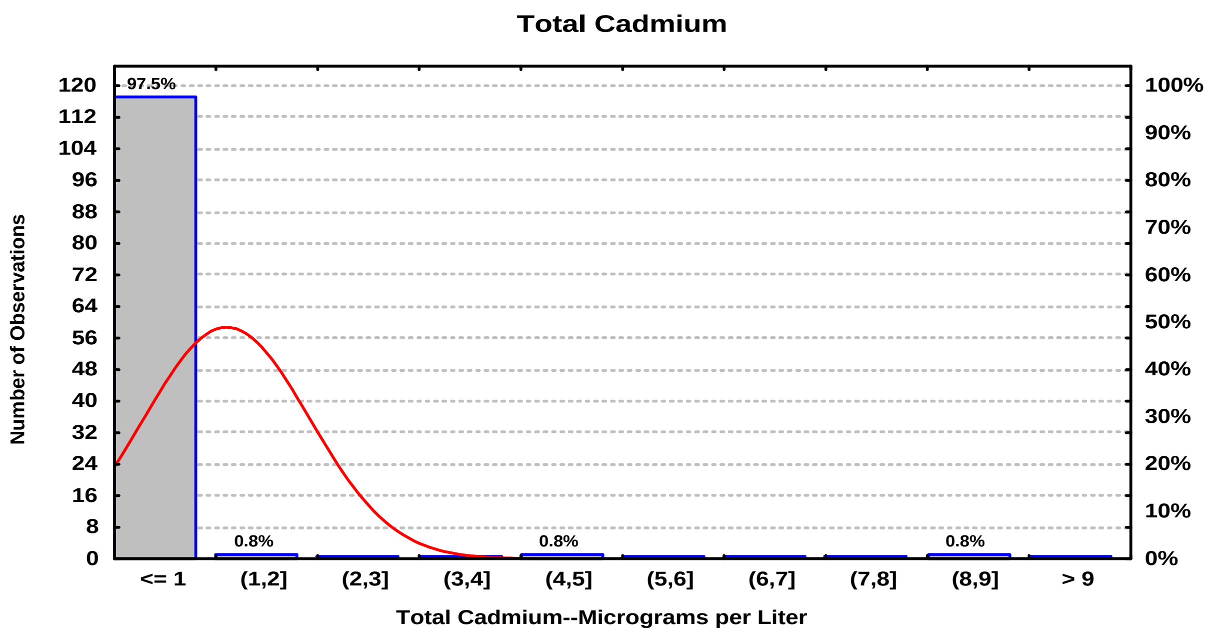




Detection limits: Micrograms per Liter Copper 1.0 Lead 1.0 Zinc 10.0

Whitewater River Basin–1997

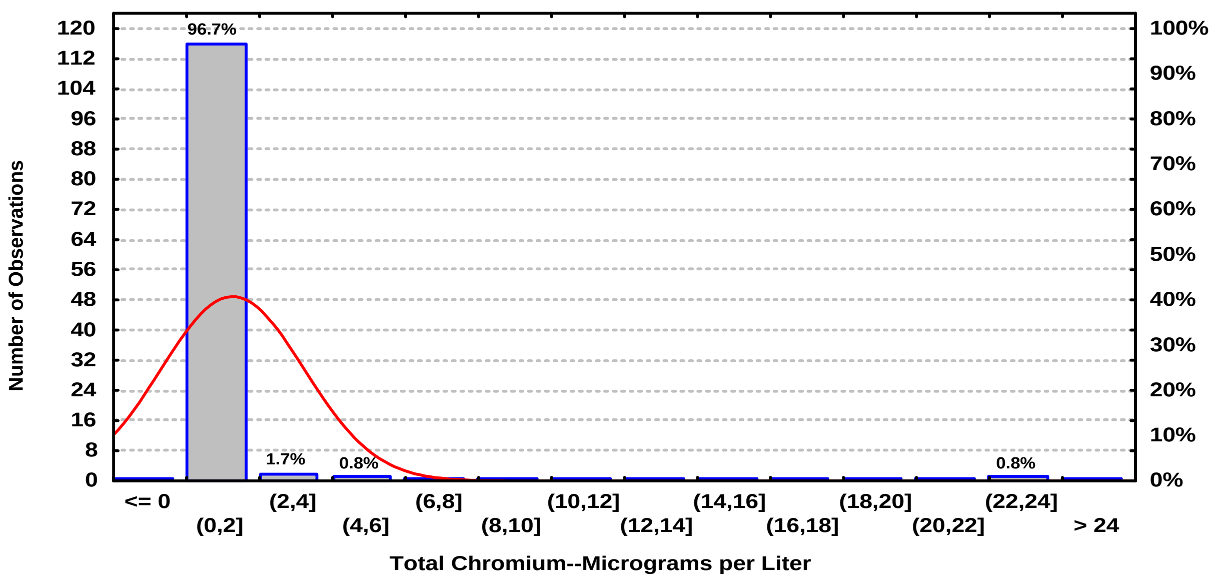




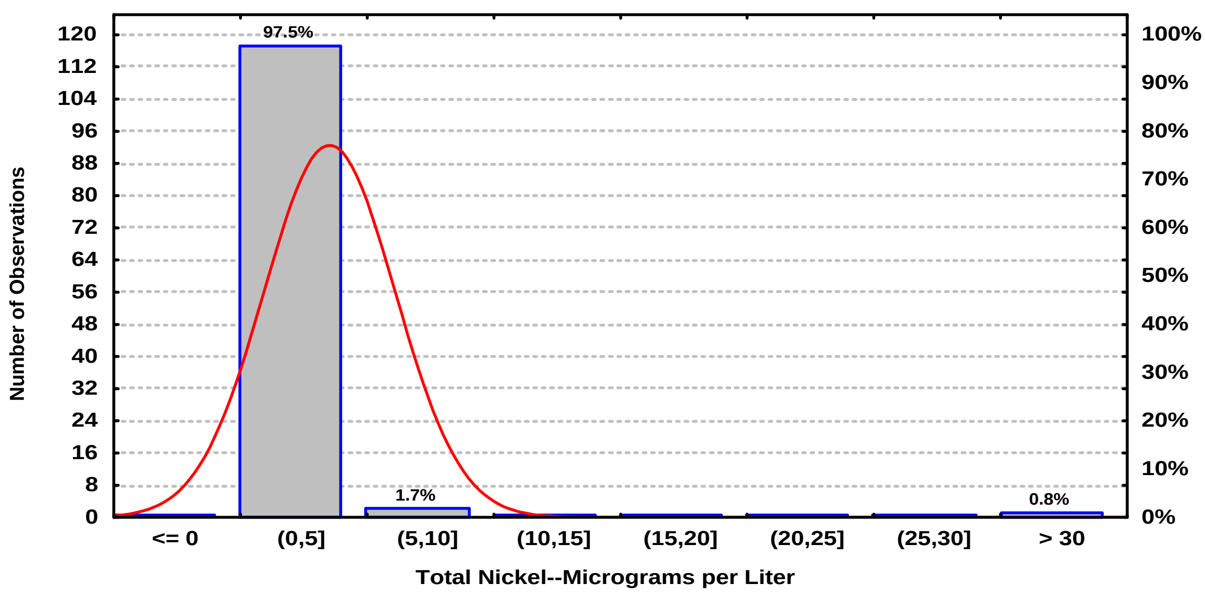
Detection limits: Micrograms per Liter Arsenic 2.0 Cadmium 1.0

Whitewater River Basin–1997

Total Chromium



Total Nickel



Detection limits: Micrograms per liter Chromium 1.0 Nickel 1.0

Appendix D

Weather Codes:

Sky Conditions:		00	North	1	Light	3	46-60
1	Clear	09	East	2	Mod/Light	5	76-85
2	Scattered	18	South	3	Moderate	6	86+
3	Partly	27	West	4	Mod/Str		
4	Cloudy			5	Strong		
5	Mist			6	Gail		
6	Fog						
7	Shower						
8	Rain						
9	Snow						
0	Sleet						
				Air Temperature:			
		Wind Strength:		1	32-		
Wind Direction:		0	Calm	2	33-45		

APPENDIX D·2
FIELD DATA RESULTS

STATION Date	Program Number	Time	Weather Code	Dissolved Oxygen mg/L	Temperature Degrees Celsius	pH SU	Turbidity NTU	Conductivity US/CM
86-01								
03/21/1997	DA10082	0830	1 18 1 2	12.15	5.94	8.29	8.50	593.00
04/30/1997	DA10208	0940	3 18 1 4	12.43	12.11	8.46	2.70	610.00
06/11/1997	DA10320	0930	2 27 1 4	9.02	18.01	8.23	18.80	583.00
07/23/1997	DA10425	0845	4 18 0 4	7.82	21.38	8.13	15.50	661.00
10/02/1997	DA10526	0850	3 27 1 3	9.10	11.02	8.24	31.20	681.00
10/02/1997	DA10527	0850						
12/04/1997	DA10985	0925	9 27 1 5	11.02	5.75	8.12	11.30	697.00
86-02								
03/20/1997	DA10081	1550	1 18 1 3	11.98	8.87	8.40	15.70	558.00
04/30/1997	DA10207	0900	3 18 0 4	10.95	11.76	8.30	5.30	631.00
04/30/1997	DA10209	0900						
06/10/1997	DA10319	1630		8.17	21.92	7.60	34.90	2.00
06/10/1997	DA10321	1630						
07/23/1997	DA10424	0915	4 18 0 5	8.39	20.07	8.15	4.35	692.00
10/02/1997	DA10528	0940	2 27 1 3	10.24	10.43	8.29	5.80	690.00
12/04/1997	DA10986	1000	9 27 1 1	11.30	6.20	8.15	2.44	645.00

If no results are listed, duplicate field data were not taken.

APPENDIX D·2
FIELD DATA RESULTS

STATION Date	Program Number	Time	Weather Code	Dissolved Oxygen mg/L	Temperature Degrees Celsius	pH SU	Turbidity NTU	Conductivity US/CM
86-03								
03/20/1997	DA10080	1515	1 18 1 3	12.82	9.51	8.42	14.60	614.00
03/20/1997	DA10083	1515						
04/29/1997	DA10206	1630	1 18 1 4	14.54	17.00	8.62	8.20	678.00
06/10/1997	DA10318	1515	1 00 0 4	9.33	19.92	8.28	31.40	662.00
07/22/1997	DA10422	1500	3 00 0 6	9.39	23.64	8.21	7.09	803.00
07/22/1997	DA10423	1500						
10/01/1997	DA10525	1540	1 27 1 4	10.11	17.23	8.21	9.70	993.00
12/03/1997	DA10983	1500	8 27 1 2	11.75	8.19	8.13	2.44	869.00
12/03/1997	DA10984	1500	8 27 1 2	11.75	8.19	8.13	2.44	869.00
86-04								
03/20/1997	DA10079	1350	1 18 1 3	12.28	9.36	8.34	16.00	605.00
04/29/1997	DA10205	1520	1 18 1 4	15.00	15.97	8.51	6.70	638.00
06/10/1997	DA10317	1420	1 00 1 4	9.33	19.84	8.23	49.30	648.00
07/22/1997	DA10421	1435	3 00 1 6	8.85	24.37	8.13	10.90	781.00
10/01/1997	DA10524	1515	1 27 2 4	11.22	17.48	8.33	7.80	840.00
12/03/1997	DA10982	1430	4 17 1 2	12.40	7.60	8.12	1.86	8.04

If no results are listed, duplicate field data were not taken.

APPENDIX D·2
FIELD DATA RESULTS

STATION Date	Program Number	Time	Weather Code	Dissolved Oxygen mg/L	Temperature Degrees Celsius	pH SU	Turbidity NTU	Conductivity US/CM
86-05								
03/20/1997	DA10078	1345	1 18 0 3	12.76	7.53	8.38	10.10	457.00
04/29/1997	DA10204	1435	1 18 1 4	11.24	13.53	8.42	3.90	468.00
06/10/1997	DA10316	1310	1 00 0 4	11.01	14.49	8.05	25.10	470.00
07/22/1997	DA10420	1335	3 00 0 6	9.04	22.72	7.96	4.50	465.00
10/01/1997	DA10523	1350	1 27 2 4	9.81	19.68	8.28	10.10	4.27
12/03/1997	DA10981	1345	4 27 1 2	11.17	8.90	8.09	3.95	440.00
87-01								
03/19/1997	DA10109	1120	1 00 0 2	12.10	4.87	8.03	32.30	550.00
05/02/1997	DA10220	1020	3 18 4 3	13.80	10.33	8.28	3.90	636.00
06/13/1997	DA10332	1220	3 27 1 5	9.11	16.74	8.14	18.80	654.00
07/25/1997	DA10436	1500	1 00 0 5	10.26	20.79	8.24	9.60	663.00
09/30/1997	DA10539	0912	1 00 4 5	8.50	14.09	7.92	18.20	678.00
12/04/1997	DA10993	0935	0 27 1 2	10.07	6.32	7.87	1.49	616.00
87-02								
03/19/1997	DA10108	1020	1 00 0 2	12.30	3.22	7.94	106.00	420.00
05/02/1997	DA10219	0925	3 21 8 3	11.34	10.44	8.22	5.50	580.00

If no results are listed, duplicate field data were not taken.

APPENDIX D·2
FIELD DATA RESULTS

STATION Date	Program Number	Time	Weather Code	Dissolved Oxygen mg/L	Temperature Degrees Celsius	pH SU	Turbidity NTU	Conductivity US/CM
87-02								
06/13/1997	DA10331	1130	3 27 1 5	9.54	18.03	8.19	12.30	597.00
07/02/1997	DA10435	1430	1 00 0 6	9.80	23.65	8.31	10.60	614.00
09/30/1997	DA10538	0939	1 00 4 4	7.70	14.24	7.88	25.00	637.00
12/04/1997	DA10994	0950	0 27 1 2	10.31	5.71	7.87	5.20	553.00
87-03								
03/19/1997	DA10107	0920	1 00 0 2	12.28	3.10	7.72	250.00	370.00
05/02/1997	DA10218	0835	3 18 1 3	10.41	10.22	8.12	19.20	598.00
06/13/1997	DA10330	1002	4 27 1 4	8.85	16.96	8.12	10.80	610.00
07/25/1997	DA10434	1330	1 00 1 6	9.50	20.99	8.25	15.10	626.00
09/30/1997	DA10537	1035	2 00 1 4	8.60	15.10	7.90	24.00	637.00
12/04/1997	DA10995	1045	4 27 1 2	10.65	6.32	7.91	4.72	581.00
87-04								
03/19/1997	DA10106	0830	1 00 1 1	12.11	3.28	8.24	63.40	516.00
05/01/1997	DA10217	1610	1 00 1 3	11.85	12.44	8.33	4.70	598.00
06/13/1997	DA10329	0904	4 27 1 4	8.74	16.52	8.14	9.00	626.00
07/25/1997	DA10433	1115	1 00 1 5	9.75	20.49	8.30	10.80	617.00

If no results are listed, duplicate field data were not taken.

APPENDIX D-2
FIELD DATA RESULTS

STATION Date	Program Number	Time	Weather Code	Dissolved Oxygen mg/L	Temperature Degrees Celsius	pH SU	Turbidity NTU	Conductivity US/CM
87-04								
09/30/1997	DA10536	1122	2 00 1 4	10.40	15.34	8.10	18.20	643.00
12/04/1997	DA10996	1135	4 27 1 2	11.16	6.83	7.98	1.16	623.00
87-05								
03/18/1997	DA10105	1620	5 00 1 2	11.28	6.58	8.16	39.50	563.00
05/01/1997	DA10216	1555	3 00 1 3	11.65	12.73	8.32	6.00	592.00
06/13/1997	DA10328	0844	4 27 1 4	8.64	17.15	8.19	16.70	622.00
07/25/1997	DA10432	1050	1 00 0 0	9.62	20.92	8.29	12.10	629.00
09/30/1997	DA10535	1213	2 00 2 4	10.60	18.20	8.20	18.20	636.00
12/04/1997	DA10997	1230	4 27 2 2	11.60	6.62	8.04	3.37	276.00
88-01								
03/18/1997	DA10104	1510	4 00 1 2	11.66	5.91	8.12	840.00	399.00
05/01/1997	DA10215	1450	3 00 1 4	11.93	13.00	8.46	4.30	543.00
06/12/1997	DA10327	1425	4 09 1 4	9.78	19.32	8.41	8.00	562.00
07/25/1997	DA10431	0908	1 00 0 4	8.97	19.69	8.18	10.90	582.00
09/29/1997	DA10534	1543	1 18 4 5	9.20	18.21	7.99	26.00	580.00
12/03/1997	DA10992	1515		11.35	7.32	8.14	1.10	591.00

If no results are listed, duplicate field data were not taken.

APPENDIX D-2
FIELD DATA RESULTS

STATION Date	Program Number	Time	Weather Code	Dissolved Oxygen mg/L	Temperature Degrees Celsius	pH SU	Turbidity NTU	Conductivity US/CM
88-02								
03/18/1997	DA10103	1450	4 00 1 2	11.20	6.90	7.98	42.10	593.00
05/01/1997	DA10214	1430	4 00 1 3	11.77	12.79	8.33	24.00	597.00
06/12/1997	DA10326	1400	4 09 1 4	8.77	18.73	8.19	37.70	628.00
07/24/1997	DA10430	1630	3 00 1 6	10.80	23.00	8.38	11.60	637.00
09/29/1997	DA10533	1517	1 18 4 5	12.58	24.50	8.30	24.50	653.00
12/03/1997	DA10991	1500	8 27 1 2	11.47	8.04	8.06	3.29	639.00
88-03								
03/18/1997	DA10102	1430	4 00 1 3	11.10	7.02	8.12	20.80	584.00
05/01/1997	DA10213	1400	4 00 1 3	10.67	12.74	8.23	8.70	586.00
06/12/1997	DA10325	1340	4 09 1 4	8.71	18.85	8.22	24.60	617.00
07/24/1997	DA10429	1600	3 00 1 6	9.83	23.53	8.36	16.90	623.00
09/29/1997	DA10532	1501	1 18 2 5	12.80	19.30	8.30	633.00	28.80
12/03/1997	DA10990	1440	7 27 1 2	11.60	8.10	8.08	3.26	626.00
88-04								
03/18/1997	DA10101	1405	3 00 1 3	11.50	6.59	8.05	15.70	441.00
05/01/1997	DA10212	1335	4 00 1 3	9.88	12.72	8.14	28.00	427.00

If no results are listed, duplicate field data were not taken.

APPENDIX D·2
FIELD DATA RESULTS

STATION Date	Program Number	Time	Weather Code	Dissolved Oxygen mg/L	Temperature Degrees Celsius	pH SU	Turbidity NTU	Conductivity US/CM
88-04								
06/12/1997	DA10324	1320	4 09 1 4	9.02	18.50	8.10	21.20	486.00
07/24/1997	DA10428	1530	3 00 1 5	8.11	25.04	8.13	69.30	408.00
09/29/1997	DA10531	1438	1 18 3 5	9.80	20.41	8.01	25.00	499.00
12/03/1997	DA10989	1405	4 27 1 2	11.30	7.32	7.95	9.49	334.00
88-05								
03/18/1997	DA10100	1330	5 00 1 3	11.56	6.73	8.08	16.70	422.00
05/01/1997	DA10211	1305	4 00 1 3	8.93	13.14	8.09	46.30	426.00
06/12/1997	DA10323	1225	4 09 1 4	8.52	19.12	8.20	22.30	76.50
07/24/1997	DA10427	1458	3 00 1 5	6.88	25.94	7.81	28.50	500.00
09/29/1997	DA10530	1417	1 18 2 5	7.74	19.28	7.60	21.00	426.00
12/03/1997	DA10988	1327	4 00 0 3	10.10	7.43	7.73	36.60	426.00
88-06								
03/18/1997	DA10099	1250	7 00 1 3	11.49	7.81	8.04	27.30	557.00
05/01/1997	DA10210	1230	4 00 1 3	10.00	13.12	8.18	15.90	544.00
06/12/1997	DA10322	1148	3 09 1 4	8.71	18.77	8.16	29.30	584.00
07/24/1997	DA10426	1305	3 00 1 5	9.50	23.69	8.27	49.30	576.00

If no results are listed, duplicate field data were not taken.

APPENDIX D·2
FIELD DATA RESULTS

STATION Date	Program Number	Time	Weather Code	Dissolved Oxygen mg/L	Temperature Degrees Celsius	pH SU	Turbidity NTU	Conductivity US/CM
88-06								
09/29/1997	DA10529	1342	1 18 1 5	10.80	20.04	8.20	608.00	25.00
12/03/1997	DA10987	1235	4 27 1 2	8.74	13.56	8.12	5.76	484.00
89-01								
03/20/1997	DA10077	1245	1 18 2 3	11.46	8.59	8.13	65.22	501.00
04/29/1997	DA10203	1410	1 18 1 4	11.90	15.89	8.35	4.30	558.00
06/10/1997	DA10315	1220	1 00 1 4	10.14	16.03	8.11	44.80	489.00
07/22/1997	DA10419	1250	5 00 1 5	9.12	23.46	8.12	6.81	573.00
10/01/1997	DA10522	1250	2 27 2 3	10.76	17.05	8.26	6.80	550.00
12/03/1997	DA10980	1250	4 27 1 2	11.75	8.30	8.19	5.13	526.00
89-02								
03/20/1997	DA10076	1200	1 18 2 3	13.05	8.03	8.23	16.40	416.00
04/29/1997	DA10202	1310		11.43	15.94	8.10	6.40	488.00
06/10/1997	DA10314	1135	1 00 1 4	9.27	16.96	8.08	31.50	387.00
07/22/1997	DA10418	1155	4 00 0 5	5.95	22.31	7.52	3.75	558.00
10/01/1997	DA10521	1145	2 27 2 3	7.45	15.94	7.43	18.00	589.00
12/03/1997	DA10979	1155	4 27 1 2	10.73	7.50	7.73	7.40	500.00

If no results are listed, duplicate field data were not taken.

APPENDIX D·2
FIELD DATA RESULTS

STATION Date	Program Number	Time	Weather Code	Dissolved Oxygen mg/L	Temperature Degrees Celsius	pH SU	Turbidity NTU	Conductivity US/CM
89-03								
03/20/1997	DA10075	1120	1 18 1 3	11.32	8.75	8.09	65.30	515.00
04/29/1997	DA10201	1230	1 18 1 4	10.50	16.30	8.20	5.30	554.00
06/10/1997	DA10313	1050	1 00 1 4	9.63	16.28	8.16	138.00	469.00
07/22/1997	DA10417	1110	4 00 0 5	8.03	24.15	8.05	11.00	545.00
10/01/1997	DA10520	1035	2 27 2 3	9.02	16.94	8.12	15.30	545.00
12/03/1997	DA10978	1115	4 18 1 2	11.75	8.80	8.12	4.59	530.00

If no results are listed, duplicate field data were not taken.

APPENDIX D·3
General Chemistry and Nutrients Results

Station Date Collected Program No.	Alkalinity mg/L	Hardness mg/L	Chloride mg/L	Sulfide mg/L	Nitrate-Nitrite mg/L	TKN mg/L	Total Phosphorus mg/L	Total Organic Carbon mg/L	Total Solids mg/L	Total Suspended Solides mg/L	Total Dissolved Solids mg/L	E. coli cfu
86-01												
03/21/1997 DA10082	240.00	330.00	27.00	36.00	3.80	0.19	0.04 UJ	1.90	350.00	< 4.00	340.00	
04/30/1997 DA10208	250.00	310.00	33.00	37.00JQ	1.70	0.51	< 0.05	2.00	370.00	< 4.00	350.00	
06/11/1997 DA10320	240.00	310.00	23.00	49.00	4.00	0.88	0.09	2.70	390.00	11.00	330.00	800.00
07/23/1997 DA10425	260.00	370.00	29.00	47.00	2.20	0.38	0.06	3.00	450.00	23.00	410.00	800.00
10/02/1997 DA10526	290.00	390.00	39.00	52.00	1.20	0.15	0.08	2.90	500.00	< 4.00	480.00	6,600.00
10/02/1997 DA10527	280.00	400.00	39.00	51.00	1.20	0.22	0.08	2.70	480.00	6.00	470.00	6,200.00
12/04/1997 DA10985	280.00	180.00 Q	33.00	65.00	1.40	0.43	0.05	3.00	450.00	< 4.00	420.00	
86-02												
03/20/1997 DA10081	230.00	280.00	22.00	45.00	2.90	0.57	0.09	2.70	360.00	5.00	330.00	
04/30/1997 DA10207	260.00	350.00	29.00	45.00Q	1.80	0.53	0.03 UJ	2.50	380.00	< 4.00	360.00	
04/30/1997 DA10209	250.00	360.00	32.00	37.00Q	1.70	0.35	0.03 UJ	2.10	380.00	< 4.00	360.00	
06/10/1997 DA10319	260.00	360.00	30.00	40.00	3.70	0.30	0.03	1.60	410.00	< 4.00	340.00	80.00 JH
06/10/1997 DA10321	280.00	350.00	30.00	39.00	3.70	0.39	< 0.05	1.80	390.00	< 4.00	360.00	100.00JH
07/23/1997 DA10424	290.00	360.00	37.00	41.00	1.40	0.28	< 0.05	2.00	420.00	< 4.00	420.00	250.00
10/02/1997 DA10528	300.00	340.00	44.00	46.00	0.53	0.10	0.03 UJ	2.30	490.00	< 4.00	470.00	40.00

Parameter Flag Definitions: B-found in blank, Q-lab duplicate QA/QC questionable, J-result estimated, U-under detection limits, H-lab holding time not met.

APPENDIX D·3
General Chemistry and Nutrients Results

Station Date Collected Program No.	Alkalinity mg/L	Hardness mg/L	Chloride mg/L	Sulfide mg/L	Nitrate-Nitrite mg/L	TKN mg/L	Total Phosphorus mg/L	Total Organic Carbon mg/L	Total Solids mg/L	Total Suspended Solides mg/L	Total Dissolved Solids mg/L	E. coli cfu
86-02												
12/04/1997 DA10986	270.00	160.00 Q	36.00	52.00	0.79	0.35	0.08	2.10	410.00	< 4.00	390.00	
86-03												
03/20/1997 DA10080	230.00	310.00	35.00	41.00	3.20	0.69	0.10	2.60	410.00	7.00	360.00	
03/20/1997 DA10083	230.00	330.00	35.00	38.00	3.20	0.47	0.09	2.90	380.00	7.00	360.00	
04/29/1997 DA10206	230.00	340.00	55.00	49.00Q	3.20	0.76	0.09	2.90	410.00	< 4.00	380.00	
06/10/1997 DA10318	250.00	320.00	42.00	61.00	4.40	0.53	0.09	2.80	420.00	8.00	380.00	120.00JH
07/22/1997 DA10422	250.00	350.00	68.00	60.00	6.20	0.50	0.12	2.00	560.00	< 4.00	520.00	340.00JH
07/22/1997 DA10423	240.00	360.00	69.00	59.00	6.30	0.16	0.16	2.00	580.00	< 4.00	510.00	390.00JH
10/01/1997 DA10525	240.00	360.00	120.00	90.00	8.80	0.28	0.35	3.90	690.00	< 4.00	700.00	40.00 JH
12/03/1997 DA10983	260.00	400.00 Q	86.00	78.00	4.60	0.54	0.10	3.40	540.00	< 4.00	500.00	
12/03/1997 DA10984	260.00	410.00 Q	85.00	78.00	4.50	1.20	0.12	3.50	530.00	< 4.00	500.00	
86-04												
03/20/1997 DA10079	230.00	320.00	32.00	37.00	3.70	0.48	0.10	2.40	380.00	6.00	360.00	
04/29/1997 DA10205	240.00	360.00	43.00	42.00Q	2.70	0.66	0.06	2.40	390.00	< 4.00	350.00	
06/10/1997 DA10317	260.00	340.00	37.00	42.00	4.60	0.47	0.07	2.40	420.00	7.00	360.00	130.00JH
07/22/1997 DA10421	250.00	350.00	63.00	52.00	5.50	0.54	0.11	2.00	500.00	7.00	480.00	170.00JH

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APPENDIX D·3
General Chemistry and Nutrients Results

Station Date Collected Program No.	Alkalinity mg/L	Hardness mg/L	Chloride mg/L	Sulfide mg/L	Nitrate-Nitrite mg/L	TKN mg/L	Total Phosphorus mg/L	Total Organic Carbon mg/L	Total Solids mg/L	Total Suspended Solides mg/L	Total Dissolved Solids mg/L	E. coli cfu
86-04												
10/01/1997 DA10524	250.00	370.00	86.00	77.00o.	5.80	0.22	0.15	4.00	560.00	6.00	630.00	< 10.00 JH
12/03/1997 DA10982	260.00	390.00 Q	74.00	71.00	4.00	0.74	0.08	3.10	500.00	< 4.00	460.00	
86-05												
03/20/1997 DA10078	180.00	230.00	23.00	35.00	2.20	0.64	0.08	3.30	280.00	6.00	260.00	
04/29/1997 DA10204	170.00	250.00	23.00	35.00Q	2.40	0.64	0.04 UJ	2.80	270.00	< 4.00	280.00	
06/10/1997 DA10316	180.00	240.00	25.00	34.00	3.10	0.53	0.05	2.90	300.00	4.00	260.00	10.00 JH
07/22/1997 DA10420	180.00	220.00	24.00	31.00	2.80	0.63	0.03 UJ	4.00	330.00	< 4.00	280.00	10.00 JH
10/01/1997 DA10523	170.00	210.00	26.00	34.00	1.50	0.44	0.04 UJ	3.80	300.00	< 4.00	260.00	< 10.00 JH
12/03/1997 DA10981	170.00	240.00 Q	25.00	37.00	1.50	0.46	0.04	3.60	280.00	< 4.00	240.00	
87-01												
03/19/1997 DA10109	230.00	320.00	18.00	33.00Q	2.80	0.60	0.11	3.00	350.00	14.00	350.00	
05/02/1997 DA10220	280.00	360.00	21.00	42.00	2.50	0.45	0.07	< 1.00	400.00	< 4.00	410.00	
06/13/1997 DA10332	290.00	380.00	21.00	37.00Q	3.60	0.52	0.07	1.80	410.00	8.00	390.00	340.00
07/25/1997 DA10436	300.00	390.00	22.00 Q	39.00	3.00	0.38	0.05	2.00	520.00	< 4.00	460.00	180.00
09/30/1997 DA10539	300.00	390.00	23.00	43.00	2.50	0.10	0.03 UJ	2.00	380.00	< 4.00	460.00	120.00
12/04/1997 DA10993	300.00	180.00 Q	23.00	40.00	2.50	0.40	0.07	1.20	420.00	< 4.00	390.00	

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APPENDIX D·3
General Chemistry and Nutrients Results

Station Date Collected Program No.	Alkalinity mg/L	Hardness mg/L	Chloride mg/L	Sulfide mg/L	Nitrate-Nitrite mg/L	TKN mg/L	Total Phosphorus mg/L	Total Organic Carbon mg/L	Total Solids mg/L	Total Suspended Solides mg/L	Total Dissolved Solids mg/L	E. coli cfu
87-02												
03/19/1997 DA10108	170.00	230.00	14.00	27.00 Q	4.00	1.20	0.22	4.30	320.00	37.00	290.00	
05/02/1997 DA10219	250.00	340.00	18.00	36.00	3.70	0.39	< 0.05	1.70	370.00	< 4.00	360.00	
06/13/1997 DA10331	260.00	340.00	19.00	33.00Q	5.40	0.52	< 0.05	1.40	400.00	< 4.00	360.00	310.00
07/02/1997 DA10435	280.00	350.00	19.00 Q	33.00	4.70	0.46	0.04 UJ	3.00	500.00	5.00	420.00	220.00
09/30/1997 DA10538	270.00	340.00	20.00	46.00	5.10	0.10	0.04 UJ	2.50	370.00	< 4.00	440.00	410.00
12/04/1997 DA10994	270.00	160.00 Q	22.00	41.00	4.20	0.90	0.05	3.20	390.00	< 4.00	360.00	
87-03												
03/19/1997 DA10107	150.00	220.00	15.00	26.00Q	3.40	1.60	0.25	4.20	410.00	140.00	270.00	
05/02/1997 DA10218	250.00	350.00	19.00	40.00	2.70	0.46	< 0.05	1.50	380.00	< 4.00	380.00	
06/13/1997 DA10330	260.00	350.00	20.00	36.00Q	4.60	0.46	< 0.05	1.10	400.00	5.00	360.00	90.00
07/25/1997 DA10434	280.00	350.00	22.00 Q	38.00	3.60	0.42	< 0.05	3.00	500.00	8.00	400.00	240.00
09/30/1997 DA10537	290.00	360.00	18.00	48.00	2.90	0.33	< 0.05	2.30	360.00	< 4.00	440.00	110.00
12/04/1997 DA10995	250.00	150.00 Q	26.00	40.00	3.30	0.74	0.05	3.00	390.00	< 4.00	340.00	
87-04												
03/19/1997 DA10106	220.00	310.00	18.00	34.00Q	3.40	0.90	0.14	2.90	380.00	45.00	340.00	
05/01/1997 DA10217	260.00	360.00	21.00	44.00	3.30	0.45	< 0.05	1.40	390.00	< 4.00	380.00	

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APPENDIX D·3
General Chemistry and Nutrients Results

Station Date Collected Program No.	Alkalinity mg/L	Hardness mg/L	Chloride mg/L	Sulfide mg/L	Nitrate-Nitrite mg/L	TKN mg/L	Total Phosphorus mg/L	Total Organic Carbon mg/L	Total Solids mg/L	Total Suspended Solides mg/L	Total Dissolved Solids mg/L	E. coli cfu
87-04												
06/13/1997 DA10329	270.00	370.00	21.00	41.00 Q	4.30	0.43	< 0.05	< 1.00	420.00	7.00	370.00	180.00
07/25/1997 DA10433	270.00	360.00	49.00 Q	39.00	3.60	0.64	0.03 UJ	3.00	480.00	5.00	410.00	320.00
09/30/1997 DA10536	290.00	380.00	20.00	42.00	3.90	0.14	< 0.05	2.20	400.00	7.00	450.00	240.00
12/04/1997 DA10996	280.00	180.00 Q	23.00	43.00	3.30	0.59	0.04	1.10	420.00	< 4.00	360.00	
88-01												
03/18/1997 DA10104	170.00	350.00	14.00	32.00Q	2.40	4.20	0.69	4.10	1,300.00	970.00	270.00	
05/01/1997 DA10215	220.00	310.00	18.00	40.00	2.90	0.46	0.04 UJ	1.90	350.00	< 4.00	350.00	
06/12/1997 DA10327	230.00	350.00	20.00	36.00Q	5.80	0.29	< 0.05	< 1.00	400.00	< 4.00	350.00	
07/25/1997 DA10431	250.00	320.00	11.00 Q	39.00	2.50	0.41	0.09	2.00	380.00	< 4.00	400.00	180.00JH
09/29/1997 DA10534	240.00	300.00	19.00	52.00	1.50	0.10	< 0.05	2.70	330.00	< 4.00	400.00	20.00 RH
12/03/1997 DA10992	260.00	180.00 Q	22.00	51.00	1.40	0.73	0.05	1.80	380.00	< 4.00	360.00	
88-02												
03/18/1997 DA10103	250.00	340.00	23.00	37.00Q	3.60	0.77	0.14	2.30	420.00	49.00	380.00	
05/01/1997 DA10214	240.00	350.00	24.00	43.00	3.00	0.57	0.07	1.60	410.00	33.00	390.00	
06/12/1997 DA10326	270.00	370.00	24.00	37.00Q	4.60	0.60	0.06	1.20	440.00	48.00	380.00	
07/24/1997 DA10430	270.00	350.00	10.00 Q	38.00	3.80	0.47	0.04 UJ	2.00	450.00	10.00	420.00	40.00 JH

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APPENDIX D·3
General Chemistry and Nutrients Results

Station Date Collected Program No.	Alkalinity mg/L	Hardness mg/L	Chloride mg/L	Sulfide mg/L	Nitrate-Nitrite mg/L	TKN mg/L	Total Phosphorus mg/L	Total Organic Carbon mg/L	Total Solids mg/L	Total Suspended Solides mg/L	Total Dissolved Solids mg/L	E. coli cfu
88-02												
09/29/1997 DA10533	260.00	330.00	29.00	40.00	3.00	0.16	< 0.05	2.00	400.00	< 4.00	440.00	10.00 RH
12/03/1997 DA10991	270.00	170.00 Q	32.00	44.00	2.70	0.45	0.09	1.60	440.00	< 4.00	380.00	
88-03												
03/18/1997 DA10102	240.00	330.00	20.00	38.00Q	3.60	0.44	0.06	1.20	370.00	17.00	370.00	
05/01/1997 DA10213	240.00	330.00	22.00	41.00	3.00	0.43	0.08	1.60	380.00	4.00	370.00	
06/12/1997 DA10325	270.00	360.00	21.00	36.00Q	4.40	0.12	< 0.05	1.20	400.00	22.00	370.00	
07/24/1997 DA10429	270.00	350.00	26.00 Q	35.00	3.70	0.62	0.03 UJ	2.00	500.00	17.00	400.00	410.00RH
09/29/1997 DA10532	260.00	310.00	30.00	57.00	3.00	0.10	0.03 UJ	< 2.00	380.00	< 4.00	430.00	
12/03/1997 DA10990	270.00	160.00 Q	30.00	41.00	2.80	0.39	0.09	1.50	410.00	< 4.00	370.00	
88-04												
03/18/1997 DA10101	190.00	240.00	10.00	30.00Q	2.20	0.63	0.03 UJ	1.70	270.00	8.00	290.00	
05/01/1997 DA10212	190.00	240.00	11.00	34.00	0.54	0.50	0.07	2.40	280.00	23.00	280.00	
06/12/1997 DA10324	220.00	280.00	12.00	28.00Q	3.60	0.59	< 0.05	1.70	320.00	14.00	290.00	
07/24/1997 DA10428	240.00	230.00	28.00 Q	25.00	0.59	0.83	0.11	3.00	340.00	44.00	270.00	
09/29/1997 DA10531	230.00	250.00	12.00	35.00	0.05	0.14	0.03 UJ	3.00	290.00	< 4.00	330.00	
12/03/1997 DA10989	200.00	120.00 Q	19.00	38.00	0.85	0.49	0.05	4.80	310.00	< 4.00	270.00	

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APPENDIX D·3
General Chemistry and Nutrients Results

Station Date Collected Program No.	Alkalinity mg/L	Hardness mg/L	Chloride mg/L	Sulfide mg/L	Nitrate-Nitrite mg/L	TKN mg/L	Total Phosphorus mg/L	Total Organic Carbon mg/L	Total Solids mg/L	Total Suspended Solides mg/L	Total Dissolved Solids mg/L	E. coli cfu
88-05												
03/18/1997 DA10100	180.00	230.00	10.00	36.00 Q	1.20	0.35	0.06	2.60	270.00	10.00	280.00	
05/01/1997 DA10211	180.00	240.00	10.00	43.00	0.24	0.61	0.13	4.00	290.00	22.00	280.00	
06/12/1997 DA10323	190.00	230.00	10.00	35.00Q	2.10	0.75	< 0.05	2.70	300.00	9.00	270.00	
07/24/1997 DA10427	230.00	270.00	21.00 Q	30.00	0.14	0.64	< 0.05	3.00	360.00	11.00	320.00	
09/29/1997 DA10530	190.00	200.00	7.30	33.00	0.05	0.24	< 0.05	3.00	250.00	< 4.00	270.00	
12/03/1997 DA10988	140.00	81.00 Q	33.00	48.00	0.48	1.10	0.17	7.90	320.00	11.00	250.00	
88-06												
03/18/1997 DA10099	240.00	300.00	17.00	35.00Q	3.70	0.37	0.09	1.50	360.00	20.00	370.00	
05/01/1997 DA10210	220.00	310.00	19.00	43.00	2.20	0.51	0.05	1.90	350.00	14.00	340.00	
06/12/1997 DA10322	250.00	330.00	19.00	34.00Q	3.60	0.55	0.05	1.40	390.00	29.00	370.00	
07/24/1997 DA10426	250.00	320.00	20.00 JQ	37.00	3.20	0.99	0.10	2.00	440.00	35.00	370.00	
09/29/1997 DA10529	230.00	300.00	27.00	56.00	2.50	0.12	0.04 UJ	2.00	370.00	< 4.00	400.00	
12/03/1997 DA10987	250.00	150.00 Q	25.00	40.00	2.20	0.69	0.09	2.00	380.00	7.00	340.00	
89-01												
03/20/1997 DA10077	200.00	290.00	17.00	32.00	3.20	0.61	0.19	3.20	380.00	33.00	290.00	
04/29/1997 DA10203	230.00	310.00	20.00	39.00Q	2.50	0.47	< 0.05	1.80	330.00	< 4.00	310.00	

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APPENDIX D·3
General Chemistry and Nutrients Results

Station Date Collected Program No.	Alkalinity mg/L	Hardness mg/L	Chloride mg/L	Sulfide mg/L	Nitrate-Nitrite mg/L	TKN mg/L	Total Phosphorus mg/L	Total Organic Carbon mg/L	Total Solids mg/L	Total Suspended Solides mg/L	Total Dissolved Solids mg/L	E. coli cfu
89-01												
06/10/1997 DA10315	190.00	260.00	21.00	33.00	3.40	0.64	0.09	2.80	340.00	24.00	270.00	250.00JH
07/22/1997 DA10419	240.00	300.00	24.00	28.00	3.00	0.62	0.05	2.00	390.00	7.00	340.00	60.00 JH
10/01/1997 DA10522	230.00	270.00	29.00	47.00	2.30	0.11	0.04 UJ	2.20	400.00	< 4.00	330.00	10.00 JH
12/03/1997 DA10980	220.00	300.00 JQ	26.00	39.00	2.00	0.45	0.07	2.80	330.00	< 4.00	300.00	
89-02												
03/20/1997 DA10076	170.00	220.00	11.00	39.00	1.00	0.17	0.08	3.90	280.00	4.00	250.00	
04/29/1997 DA10202	220.00	280.00	12.00	49.00Q	0.22	0.52	0.05 UJ	2.40	310.00	< 4.00	290.00	
06/10/1997 DA10314	170.00	210.00	8.70	30.00	2.30	0.95	0.08	4.20	280.00	10.00	240.00	800.00JH
07/22/1997 DA10418	240.00	280.00	14.00	38.00	0.74	0.58	< 0.05	2.00	370.00	< 4.00	340.00	220.00JH
10/01/1997 DA10521	280.00	320.00	18.00	38.00	0.13	0.15	0.07	2.70	400.00	12.00	390.00	380.00RH
12/03/1997 DA10979	190.00	320.00 Q	20.00	72.00	0.60	0.37	0.08	3.20	330.00	4.00	310.00	
89-03												
03/20/1997 DA10075	210.00	290.00	17.00	35.00	3.00	0.52	0.16	3.30	400.00	49.00	300.00	
04/29/1997 DA10201	230.00	310.00	20.00	35.00Q	2.30	0.42	< 0.05	1.70	330.00	< 4.00	310.00	
06/10/1997 DA10313	200.00	230.00	19.00	30.00	3.30	0.80	0.17	3.00	400.00	91.00	270.00	
07/22/1997 DA10417	220.00	270.00	23.00	35.00	3.10	0.57	0.05	2.00	370.00	13.00	340.00	300.00JH

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APPENDIX D·3
General Chemistry and Nutrients Results

Station Date Collected Program No.	Alkalinity mg/L	Hardness mg/L	Chloride mg/L	Sulfide mg/L	Nitrate-Nitrite mg/L	TKN mg/L	Total Phosphorus mg/L	Total Organic Carbon mg/L	Total Solids mg/L	Total Suspended Solides mg/L	Total Dissolved Solids mg/L	E. coli cfu
89-03												
10/01/1997 DA10520	240.00	280.00	29.00	35.00	2.00	0.15	0.05 UJ	2.20	400.00	8.00	400.00	50.00 RH
12/03/1997 DA10978	210.00	290.00 Q	27.00	38.00	1.80	0.75	0.10	3.30	320.00	< 4.00	290.00	

Parameter Flag Definitions: B-found in blank, Q-lab duplicate QA/QC questionable, J-result estimated, U-under detection limits, H-lab holding time not met.

APPENDIX D·4
Total Recoverable Metals

STATION DATE LAB NUMBER	Arsenic ug/l	Cadmium ug/l	Total Chromium ug/l	Copper ug/l	Iron ug/l	Lead ug/l	Mercury ug/l	Nickel ug/l	Zinc ug/l
86-01 03/21/1997 DA10082	< 2.00	< 1.00	< 1.00	1.40	151.00	< 1.00	< 0.20	3.80	< 10.00
04/30/1997 DA10208	< 2.00	< 1.00	< 1.00	1.50 Q	< 100.00	< 1.00	< 0.20	3.00	< 10.00
06/11/1997 DA10320	< 2.00	< 1.00	< 1.00	1.70	459.00	< 1.00	< 0.20	2.60 Q	< 10.00 Q
07/23/1997 DA10425	< 2.00	< 1.00	1.10	4.10	900.00	5.20	< 0.20	4.50	15.40
10/02/1997 DA10526	< 2.00	< 1.00	< 1.00	3.60	323.00	< 1.00	< 0.20	3.60	12.50
10/02/1997 DA10527	< 2.00	< 1.00	< 1.00	3.30	330.00	< 1.00	< 0.20	3.60	< 10.00
12/04/1997 DA10985	< 2.00	< 1.00	< 1.00	< 2.70	317.00	< 1.00	< 0.20	3.60	< 10.00
86-02 03/20/1997 DA10081	< 2.00	< 1.00	< 1.00	1.60	455.00	< 1.00	< 0.20	3.70	< 10.00
04/30/1997 DA10207	< 2.00	< 1.00	< 1.00	1.50 Q	< 100.00	< 1.00	< 0.20	4.00	< 10.00
04/30/1997 DA10209	< 2.00	< 1.00	< 1.00	1.50 Q	< 100.00	< 1.00	< 0.20	3.60	< 10.00
06/10/1997 DA10319	< 2.00	< 1.00	< 1.00	1.20	< 100.00	< 1.00	< 0.20	2.30 Q	< 10.00 Q
06/10/1997 DA10321	< 2.00	< 1.00	< 1.00	1.20	< 100.00	< 1.00	< 0.20	2.20 Q	< 10.00 Q
07/23/1997 DA10424	< 2.00	< 1.00	< 1.00	2.40	< 100.00	< 1.00	< 0.20	3.80	< 10.00

Parameter Flag Definitions: B-found in blank, Q-lab duplicate QA/QC questionable, J-result estimated, U-under detection limits, H-lab holding time not met.

APPENDIX D-4
Total Recoverable Metals

STATION DATE LAB NUMBER	Arsenic ug/l	Cadmium ug/l	Total Chromium ug/l	Copper ug/l	Iron ug/l	Lead ug/l	Mercury ug/l	Nickel ug/l	Zinc ug/l
10/02/1997 DA10528	< 2.00	< 1.00	< 1.00	2.40	105.00	< 1.00	< 0.20	3.30	< 10.00
12/04/1997 DA10986	< 2.00	< 1.00	< 1.00	< 2.00	149.00	< 1.00	< 0.20	3.20	< 10.00
86-03 03/20/1997 DA10080	< 2.00	< 1.00	< 1.00	2.10	367.00	< 1.00	< 0.20	4.20	< 10.00
03/20/1997 DA10083	< 2.00	< 1.00	< 1.00	2.20	390.00	< 1.00	< 0.20	4.10	10.90
04/29/1997 DA10206	< 2.00	< 1.00	< 1.00	2.40 Q	124.00	< 1.00	< 0.20	3.70	< 10.00
06/10/1997 DA10318	< 2.00	< 1.00	< 1.00	1.90	213.00	< 1.00	< 0.20	2.80 Q	10.30 Q
07/22/1997 DA10422	< 2.00	< 1.00	< 1.00	3.00	224.00	< 1.00	< 0.20	4.40	10.70
07/22/1997 DA10423	< 2.00	< 1.00	< 1.00	2.90	223.00	< 1.00	< 0.20	4.60	17.90
10/01/1997 DA10525	< 2.00	< 1.00	< 1.00	4.20	151.00	< 1.00	< 0.20	5.10	21.60
12/03/1997 DA10983	< 2.00	< 1.00	< 1.00	< 3.10	106.00	< 1.00	< 0.20	4.10	13.60
12/03/1997 DA10984	< 2.00	< 1.00	< 1.00	< 3.20	153.00	< 1.00	< 0.20	4.20	14.90
86-04 03/20/1997 DA10079	< 2.00	< 1.00	< 1.00	1.80	339.00	< 1.00	< 0.20	4.00	< 10.00
04/29/1997 DA10205	< 2.00	< 1.00	1.00	1.80 Q	< 100.00	< 1.00	< 0.20	3.70	< 10.00

Parameter Flag Definitions: B-found in blank, Q-lab duplicate QA/QC questionable, J-result estimated, U-under detection limits, H-lab holding time not met.

APPENDIX D-4
Total Recoverable Metals

STATION DATE LAB NUMBER	Arsenic ug/l	Cadmium ug/l	Total Chromium ug/l	Copper ug/l	Iron ug/l	Lead ug/l	Mercury ug/l	Nickel ug/l	Zinc ug/l
06/10/1997 DA10317	< 2.00	< 1.00	< 1.00	1.70	289.00	< 1.00	< 0.20	2.50 Q	< 10.00 Q
07/22/1997 DA10421	< 2.00	< 1.00	< 1.00	2.50	325.00	< 1.00	< 0.20	4.30	< 10.00
10/01/1997 DA10524	< 2.00	< 1.00	< 1.00	3.30	140.00	< 1.00	< 0.20	4.70	13.90
12/03/1997 DA10982	< 2.00	< 1.00	1.50	2.60	< 100.00	< 1.00	< 0.20	4.40	12.60
86-05									
03/20/1997 DA10078	< 2.00	< 1.00	< 1.00	1.60	215.00	< 1.00	< 0.20	3.60	< 10.00
04/29/1997 DA10204	< 2.00	< 1.00	< 1.00	1.30 Q	< 100.00	< 1.00	< 0.20	2.90	< 10.00
06/10/1997 DA10316	< 2.00	< 1.00	< 1.00	1.10	312.00	< 1.00	< 0.20	2.30 Q	< 10.00 Q
07/22/1997 DA10420	< 2.00	< 1.00	< 1.00	1.00	< 100.00	< 1.00	< 0.20	2.60	< 10.00
10/01/1997 DA10523	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	2.20	26.80
12/03/1997 DA10981	< 2.00	< 1.00	< 1.00	< 1.00	101.00	< 1.00	< 0.20	2.20	< 10.00
87-01									
03/19/1997 DA10109	< 2.00	< 1.00	< 1.00	2.00	836.00	< 1.00	< 0.20	4.20	< 10.00
05/02/1997 DA10220	< 2.00	< 1.00	2.80	< 1.00	< 100.00	< 1.00	< 0.20	4.70	< 10.00
06/13/1997 DA10332	< 2.00	< 1.00	< 1.00	1.10	279.00	< 1.00	< 0.20	3.10	< 10.00

Parameter Flag Definitions: B-found in blank, Q-lab duplicate QA/QC questionable, J-result estimated, U-under detection limits, H-lab holding time not met.

APPENDIX D·4
Total Recoverable Metals

STATION DATE LAB NUMBER	Arsenic ug/l	Cadmium ug/l	Total Chromium ug/l	Copper ug/l	Iron ug/l	Lead ug/l	Mercury ug/l	Nickel ug/l	Zinc ug/l
07/25/1997 DA10436	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	2.30	< 10.00
09/30/1997 DA10539	< 2.00	< 1.00	1.30	< 1.00	< 100.00	< 1.00	< 0.20	3.10	< 10.00
12/04/1997 DA10993	< 2.00	9.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	2.80	< 10.00
87-02									
03/19/1997 DA10108	< 2.00	< 1.00	2.30	3.30	3,120.00	2.10	< 0.20	4.80	14.20
05/02/1997 DA10219	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	3.80	< 10.00
06/13/1997 DA10331	< 2.00	< 1.00	< 1.00	< 1.00	144.00	< 1.00	< 0.20	2.70	< 10.00
07/02/1997 DA10435	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	2.30	< 10.00
09/30/1997 DA10538	< 2.00	< 1.00	< 1.00	< 1.00	152.00	< 1.00	< 0.20	3.20	< 10.00
12/04/1997 DA10994	< 2.00	< 1.00	< 1.00	< 1.00	136.00	< 1.00	< 0.20	2.80	< 10.00
87-03									
03/19/1997 DA10107	< 2.00	< 1.00	4.60	5.50	6,970.00	4.60	< 0.20	6.90	26.50
05/02/1997 DA10218	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	3.50	< 10.00
06/13/1997 DA10330	< 2.00	< 1.00	< 1.00	< 1.00	166.00	< 1.00	< 0.20	2.90	< 10.00
07/25/1997 DA10434	< 2.00	< 1.00	< 1.00	2.20	< 100.00	< 1.00	< 0.20	2.50	< 10.00

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APPENDIX D·4
Total Recoverable Metals

STATION DATE LAB NUMBER	Arsenic ug/l	Cadmium ug/l	Total Chromium ug/l	Copper ug/l	Iron ug/l	Lead ug/l	Mercury ug/l	Nickel ug/l	Zinc ug/l
09/30/1997 DA10537	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	3.10	< 10.00
12/04/1997 DA10995	< 2.00	< 1.00	< 1.00	< 1.00	170.00	< 1.00	< 0.20	2.70	< 10.00
87-04 03/19/1997 DA10106	< 2.00	< 1.00	< 1.00	2.10	1,820.00	1.50	< 0.20	4.50	< 10.00
05/01/1997 DA10217	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	3.40	< 10.00
06/13/1997 DA10329	< 2.00	< 1.00	< 1.00	< 1.00	148.00	< 1.00	< 0.20	2.60	< 10.00
07/25/1997 DA10433	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	2.30	< 10.00
09/30/1997 DA10536	< 2.00	< 1.00	< 1.00	< 1.00	212.00	< 1.00	< 0.20	3.30	< 10.00
12/04/1997 DA10996	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	2.80	< 10.00
87-05									
03/18/1997 DA10105	< 2.00	< 1.00	< 1.00	1.90	964.00	< 1.00	< 0.20	4.30	< 10.00
05/01/1997 DA10216	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	3.60	< 10.00
06/13/1997 DA10328	< 2.00	< 1.00	< 1.00	< 1.00	285.00	< 1.00	< 0.20	2.60	< 10.00
07/25/1997 DA10432	< 2.00	< 1.00	< 1.00	< 1.00	104.00	< 1.00	< 0.20	2.40	< 10.00
09/30/1997 DA10535	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	3.20	23.30

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APPENDIX D·4
Total Recoverable Metals

STATION DATE LAB NUMBER	Arsenic ug/l	Cadmium ug/l	Total Chromium ug/l	Copper ug/l	Iron ug/l	Lead ug/l	Mercury ug/l	Nickel ug/l	Zinc ug/l
12/04/1997 DA10997	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	2.90	< 10.00
88-01									
03/18/1997 DA10104	14.00	< 5.00	22.10	27.00	27,600.00	27.50	< 0.20	30.30	149.00
05/01/1997 DA10215	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	2.90	< 10.00
06/12/1997 DA10327	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	2.50	< 10.00
07/25/1997 DA10431	< 2.00	< 1.00	1.20	< 1.00	< 100.00	< 1.00	< 0.20	2.30	< 10.00
09/29/1997 DA10534	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	2.60	17.00
12/03/1997 DA10992	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	2.70	< 10.00
88-02									
03/18/1997 DA10103	< 2.00	< 1.00	1.40	2.10	1,210.00	1.40	< 0.20	4.50	11.30
05/01/1997 DA10214	< 2.00	< 1.00	1.60	1.50	658.00	< 1.00	< 0.20	4.40	24.60
06/12/1997 DA10326	< 2.00	< 1.00	< 1.00	1.70	964.00	1.20	< 0.20	3.40	10.20
07/24/1997 DA10430	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	2.40	< 10.00
09/29/1997 DA10533	< 2.00	< 1.00	< 1.00	1.00	122.00	< 1.00	< 0.20	3.30	< 10.00
12/03/1997 DA10991	< 2.00	< 1.00	< 1.00	< 1.00	102.00	< 1.00	< 0.20	2.80	< 10.00

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APPENDIX D·4
Total Recoverable Metals

STATION DATE LAB NUMBER	Arsenic ug/l	Cadmium ug/l	Total Chromium ug/l	Copper ug/l	Iron ug/l	Lead ug/l	Mercury ug/l	Nickel ug/l	Zinc ug/l
88-03									
03/18/1997 DA10102	< 2.00	< 1.00	< 1.00	1.50	465.00	< 1.00	< 0.20	3.70	< 10.00
05/01/1997 DA10213	< 2.00	< 1.00	< 1.00	< 1.00	102.00	< 1.00	< 0.20	3.50	< 10.00
06/12/1997 DA10325	< 2.00	< 1.00	< 1.00	1.20	504.00	< 1.00	< 0.20	2.90	11.90
07/24/1997 DA10429	< 2.00	< 1.00	< 1.00	1.10	120.00	< 1.00	< 0.20	2.60	< 10.00
09/29/1997 DA10532	< 2.00	< 1.00	< 1.00	1.20	< 100.00	< 1.00	< 0.20	3.30	< 10.00
12/03/1997 DA10990	< 2.00	1.60	< 1.00	1.10	< 100.00	< 1.00	< 0.20	3.00	< 10.00
88-04									
03/18/1997 DA10101	< 2.00	< 1.00	< 1.00	< 1.00	389.00	< 1.00	< 0.20	3.40	< 10.00
05/01/1997 DA10212	< 2.00	< 1.00	< 1.00	1.10	519.00	< 1.00	< 0.20	3.10	< 10.00
06/12/1997 DA10324	< 2.00	< 1.00	< 1.00	1.10	431.00	< 1.00	< 0.20	2.30	< 10.00
07/24/1997 DA10428	< 2.00	< 1.00	1.10	1.60	405.00	1.10	< 0.20	2.70	< 10.00
09/29/1997 DA10531	< 2.00	< 1.00	< 1.00	< 1.00	149.00	< 1.00	< 0.20	2.90	< 10.00
12/03/1997 DA10989	< 2.00	< 1.00	< 1.00	< 1.30	292.00	< 1.00	< 0.20	2.60	< 10.00
88-05									
03/18/1997 DA10100	< 2.00	< 1.00	< 1.00	1.00	398.00	< 1.00	< 0.20	3.10	< 10.00

Parameter Flag Definitions: B-found in blank, Q-lab duplicate QA/QC questionable, J-result estimated, U-under detection limits, H-lab holding time not met.

APPENDIX D·4
Total Recoverable Metals

STATION DATE LAB NUMBER	Arsenic ug/l	Cadmium ug/l	Total Chromium ug/l	Copper ug/l	Iron ug/l	Lead ug/l	Mercury ug/l	Nickel ug/l	Zinc ug/l
05/01/1997 DA10211	< 2.00	< 1.00	1.20	1.50	916.00	< 1.00	< 0.20	3.80	10.70
06/12/1997 DA10323	< 2.00	< 1.00	< 1.00	< 1.00	402.00	< 1.00	< 0.20	2.20	< 10.00
07/24/1997 DA10427	< 2.00	< 1.00	< 1.00	< 1.00	173.00	< 1.00	< 0.20	2.50	< 10.00
09/29/1997 DA10530	< 2.00	< 1.00	< 1.00	< 1.00	226.00	< 1.00	< 0.20	2.80	< 10.00
12/03/1997 DA10988	< 2.00	< 1.00	< 1.00	< 2.80	963.00	1.00	< 0.20	3.20	10.90
88-06									
03/18/1997 DA10099	< 2.00	< 1.00	< 1.00	1.50	595.00	< 1.00	< 0.20	4.10	10.60
05/01/1997 DA10210	< 2.00	< 1.00	< 1.00	1.30	300.00	< 1.00	< 0.20	3.80	< 10.00
06/12/1997 DA10322	< 2.00	< 1.00	< 1.00	1.40	703.00	< 1.00	< 0.20	2.80	< 10.00
07/24/1997 DA10426	< 2.00	< 1.00	1.30	1.50	313.00	< 1.00	< 0.20	2.90	< 10.00
09/29/1997 DA10529	< 2.00	< 1.00	< 1.00	< 1.00	< 100.00	< 1.00	< 0.20	3.10	< 10.00
12/03/1997 DA10987	< 2.00	< 1.00	< 1.00	< 1.00	171.00	< 1.00	< 0.20	2.80	< 10.00
89-01 03/20/1997 DA10077	< 2.00	< 1.00	1.50	2.30	1,560.00	1.40	< 0.20	4.40	< 10.00
04/29/1997 DA10203	< 2.00	< 1.00	1.00	< 1.00 Q	< 100.00	< 1.00	< 0.20	3.20	< 10.00

Parameter Flag Definitions: B-found in blank, Q-lab duplicate QA/QC questionable, J-result estimated, U-under detection limits, H-lab holding time not met.

APPENDIX D·4
Total Recoverable Metals

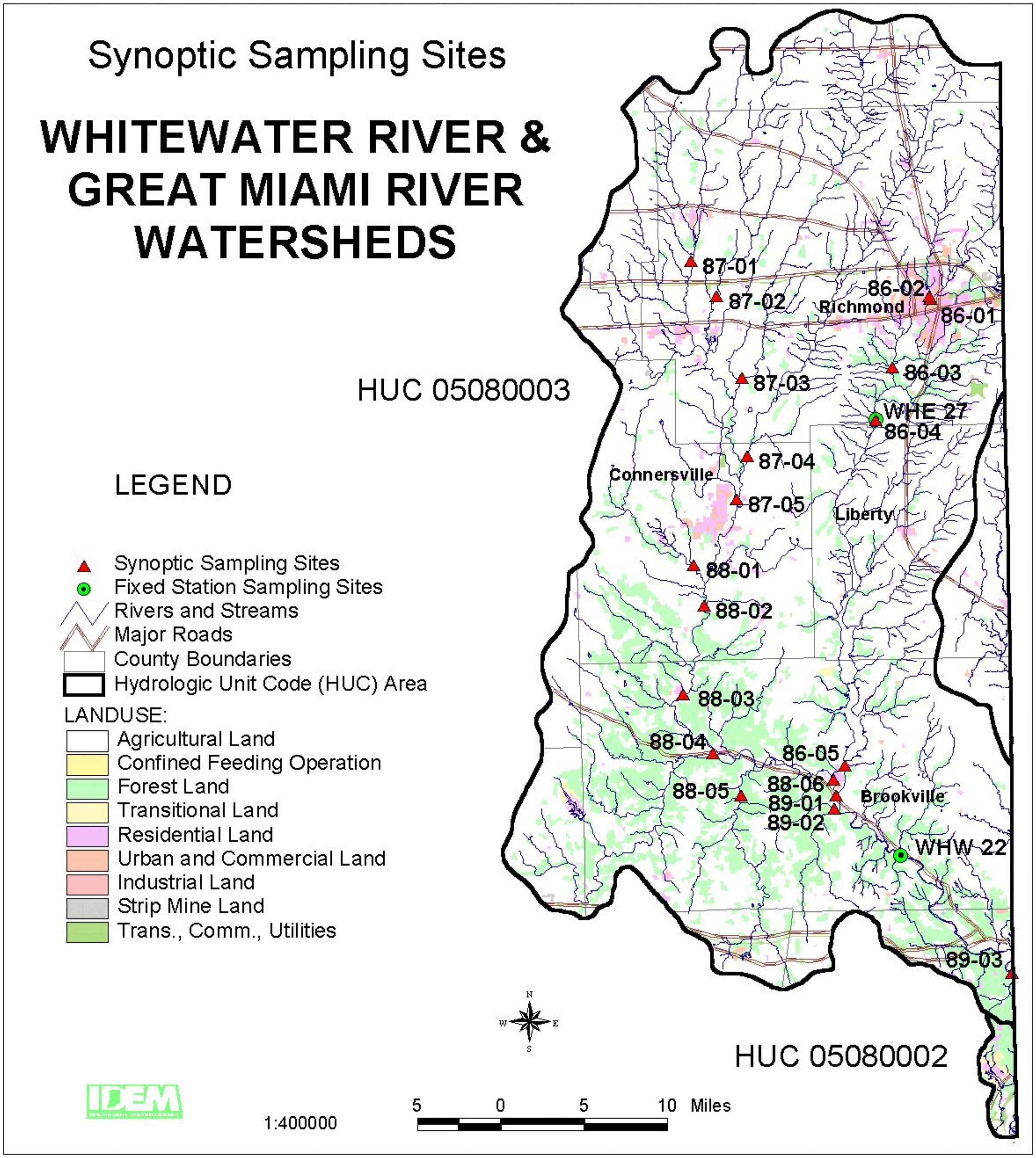
STATION DATE LAB NUMBER	Arsenic ug/l	Cadmium ug/l	Total Chromium ug/l	Copper ug/l	Iron ug/l	Lead ug/l	Mercury ug/l	Nickel ug/l	Zinc ug/l
06/10/1997 DA10315	< 2.00	< 1.00	< 1.00	1.50	781.00	1.20	< 0.20	2.60 Q	10.00 Q
07/22/1997 DA10419	< 2.00	< 1.00	< 1.00	< 1.00	171.00	< 1.00	< 0.20	3.30	< 10.00
10/01/1997 DA10522	< 2.00	< 1.00	< 1.00	< 1.00	108.00	< 1.00	< 0.20	3.20	< 10.00
12/03/1997 DA10980	< 2.00	< 1.00	< 1.00	< 1.00	121.00	< 1.00	< 0.20	2.60	< 10.00
89-02									
03/20/1997 DA10076	< 2.00	< 1.00	< 1.00	1.20	382.00	< 1.00	< 0.20	3.20	< 10.00
04/29/1997 DA10202	< 2.00	< 1.00	< 1.00	< 1.00 Q	101.00	< 1.00	< 0.20	3.20	< 10.00
06/10/1997 DA10314	< 2.00	< 1.00	< 1.00	1.40	623.00	< 1.00	< 0.20	2.30 Q	< 10.00 Q
07/22/1997 DA10418	< 2.00	< 1.00	< 1.00	< 1.00	182.00	< 1.00	< 0.20	3.60	< 10.00
10/01/1997 DA10521	< 2.00	< 1.00	< 1.00	< 1.00	448.00	< 1.00	< 0.20	4.20	< 10.00
12/03/1997 DA10979	< 2.00	< 1.00	< 1.00	< 1.10	217.00	< 1.00	< 0.20	2.80	< 10.00
89-03 03/20/1997 DA10075	< 2.00	< 1.00	1.50	2.30	1,680.00	1.60	< 0.20	4.60	< 10.00
04/29/1997 DA10201	< 2.00	< 1.00	< 1.00	< 1.00 Q	< 100.00	< 1.00	< 0.20	2.90	< 10.00
06/10/1997 DA10313	< 2.00	< 1.00	1.20	2.30	1,720.00	1.70	< 0.20	3.40 Q	108.00 Q

Parameter Flag Definitions: B-found in blank, Q-lab duplicate QA/QC questionable, J-result estimated, U-under detection limits, H-lab holding time not met.

APPENDIX D·4
Total Recoverable Metals

STATION DATE LAB NUMBER	Arsenic ug/l	Cadmium ug/l	Total Chromium ug/l	Copper ug/l	Iron ug/l	Lead ug/l	Mercury ug/l	Nickel ug/l	Zinc ug/l
07/22/1997 DA10417	< 2.00	< 1.00	< 1.00	1.00	303.00	< 1.00	< 0.20	3.00	< 10.00
10/01/1997 DA10520	< 2.00	< 1.00	< 1.00	< 1.00	194.00	< 1.00	< 0.20	3.10	< 10.00
12/03/1997 DA10978	< 2.00	< 1.00	< 1.00	< 1.00	115.00	< 1.00	< 0.20	2.70	< 10.00

Parameter Flag Definitions: B-found in blank, Q-lab duplicate QA/QC questionable, J-result estimated, U-under detection limits, H-lab holding time not met.



Map Reference

Projection:	UTM, Zone 16
Datum:	NAD 83
Printed:	June 1999
Plate Preparation:	Joanna Wood

IDEM/Office of Water Management
Assessment Branch/Surveys Section

Plate 1 - Whitewater River & Great Miami River Watersheds

Indiana Department of Environmental Management (1999). *1997 Synoptic Sampling Surveys in the East Fork of the White River Basin,* by Mark Holdeman, et. al., Indiana Department of Environmental Management, Office of Water Management, Assessment Branch, Surveys Section, Indianapolis, Indiana. IDEM 32/02/010/1999.